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FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

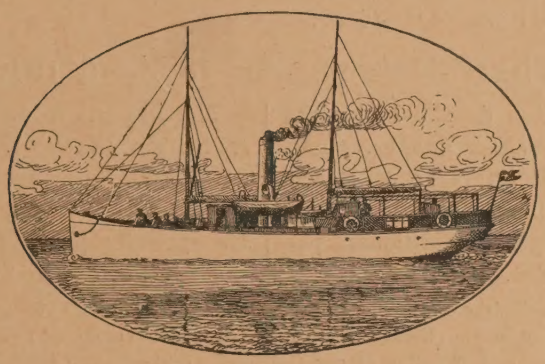
Report

of

The Danish Biological Station

to

The Board of Agriculture.



XXVIII.

1922.

By

C. G. Joh. Petersen,
Ph. D., L. L. D.
Director.

Copenhagen.
In Commission by G. E. C. Gad.
Centraltrykkeriet (C. Ferslew).
1922.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen 1888. 8°. 162 pg. 2 Kort.

Det videnskabelige Udbytte af Kanonbaaden »Hauch«s Togter i de danske Have indenfor Skagen. 1893. 4°. 464 pg. Atlas i folio.

Indhold: Echinodermata (Petersen), Diatomeer (Cleve), Undersøgelse af nogle Bundprøver (Rørdam), Mollusca (Petersen), Cephalopoda (Posselt), Crustacea malacostraca (Meinert), Hydrografi (Rørdam), Polyzoa (Levinsen), Ascidiæ simplices (Traustedt), Annulata, Hydroidæ, Anthozoa, Porifera (Levinsen), Nogle alm. Resultater (General Results, Engl.) (Petersen).

C. F. Drechsel: Oversigt over vore Saltvandsfiskerier med Kort og Planer. 1890. 4°, 100 pg. Med et Tillæg: »Om Naturforholdene indenfor Skagen« af *C. G. Joh. Petersen.* Med Kort. 4°. 46 pg.

Fiskeri-Beretning for $18^{88}/_{89}$ til 1916.

Beretninger fra den danske biologiske Station findes paa dansk publiceret i de tilsvarende Fiskeri-Beretninger, til Beretning XXI med Tillæg. Senere udgives de som selvstændige Publicationer paa Dansk og paa Engelsk.

The Reports from The Danish Biological Station are also published in Danish in the corresponding Fiskeri-Beretning, until Report XXI with Appendix. Later on they are specially published in Danish and in English, but not in the Fiskeri-Beretning.

I. Fiskenes biologiske Forhold i Holbæk Fjord. (1890—91.)*) 63 pg. Med et Kort.
II. Om vore Kutlingers *(Gobius)* Æg og Ynglemaade. (1891—92.) 9 pg. Med 2 Tavler.
II. On the Eggs and Breeding of our Gobiidæ. (1891—92.) 9 pg. Two Plates.
III. Det pelagiske Liv i Fænø Sund etc. (1892—93.) 38 pg. Tabeller.
III. The Pelagic Life in Fænø Sound etc. (1892—93.) 38 pg. Tables.
IV. Om vore Flynderfiskes Biologi og om vore Flynderfiskeriers Aftagen. (1893—94.) 146 pg. 2 Tavler. 1 Kort og mange Tabeller.
IV. On the Biology of our Flat-fishes and on the decrease of our Flat-fish Fisheries. (1893—94.) 146 pg. 2 Plates. 1 Chart. Many Tables.
V. Den alm. Aal (*Anguilla vulgaris* T.) anlægger før sin Vandring til Havet en særlig Forplantningsdragt. (1894—95.) 35 pg. Med 2 Tavler.
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V. The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. (1894—95.) 35 pg. With 2 Plates.
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VI. The Yearly Immigration of young Plaice into the Limfjord etc. (1895—96.) 48 pg. 1 Chart. 2 Tables.
VII. Plankton-Studier i Limfjorden. (1896—97.) 23 pg. 1 Kort. 4 Tabeller.
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VIII. Om et Skovl-Vaad til Undersøgelse af dybere Farvande. (1897—98.) 24 pg. 10 Figurer.
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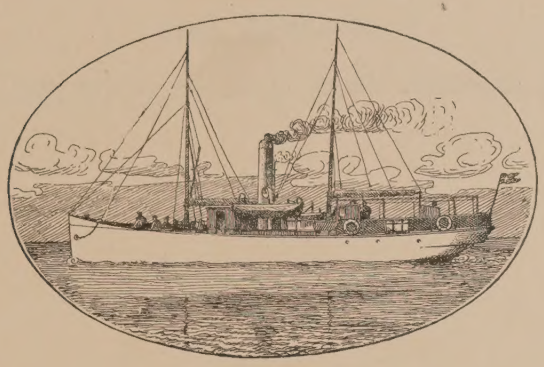

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On the Biology of some Danish Gammarids and Mysids.

(Gammarus locusta, Mysis flexuosa, Mysis neglecta, Mysis inermis.)

By

H. Blegvad.

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Introduction.

During the investigations of the Danish Biological Station on the ecology of the sea (Reports from the Dan. Biol. Station XX-XXVI), it has often been noted that in spite of quantitative measurements periodically executed of the amount of animals present within a limited area of the sea bottom, no idea referring to the productive capacity of this area could be obtained until a better knowledge about the biology of the animals in question was obtained, or at any rate, of the most important ones, especially with regard to rate of growth, duration of life, and power of multiplication. It is obvious that an area of the sea bottom containing a community of perennial animals may have a far less productive capacity than a similar bottom area containing a community of annual animals or even animals, which bring forth several generations during the year, notwithstanding the fact that the amount of animals during the whole year may possibly be greatest in the first named place (see C. G. Joh. Petersen (19, 1911) p. 57-58). It has seemed particularly astonishing that the region, from which one naturally might expect the greatest annual production, viz, the plant belt, has a comparatively small amount of animals per square metre in proportion to the deeper, bare areas of the sea-bottom outside it. By taking quantitative net samples at regular intervals during the whole year in different parts of the plant belt of our waters (see 19, 1918 p. 39), it has appeared that the only animals, which are of noteworthy consequence as to mass during a short period of the year, are the small gastropods, and above all, *Rissoa membranacea*. In my paper treating the matter of food of fishes in the Danish waters (4, 1917) I have on page 48 shown the remarkable fact that the numerous fishes of the plant belt do not, as might be expected, feed mainly on *Rissoa*, but on *crustaceans*, which are so sparely represented in the above named net samples that they may be said to belong to the comparatively less frequent animals. I have previously (l. c. p. 48) calculated, based upon qantitative fishing experiments in the Nyborg Fjord that merely a little species of fish as our common spotted goby *(Gobius ruthensparri)*, consumes annually about 86 g small crustaceans on each square metre bottom area. These crustaceans are, besides Copepods, mainly Gammarids and Mysids, and as the net samples contain only quite small amounts of the two last named species (mostly less than 1 g per square metre, in no

places above 10 g per square metre), I could during the elaboration of my above named paper not avoid the theory which, in fact, has been set forth there p. 49, that some of the small crustaceans in the plant belt of our coasts may possibly produce several successive generations per annum.

The crustaceans which are of special interest as fish food at our coasts, occuring again and again in the stomach contents of our young fishes, cod, eel, viviparous blenny, dab etc. are Gammarids, Mysids, *Idothea* (especially *I. baltica)*, shrimps *(Crangon vulgaris)* and crabs *(Carcinus mœnas)*. The most frequent and largest species of Gammarids and Mysids in our waters, which I, therefore, have particularly examined in the present paper, are the following:

Gammarus locusta Linné.
Mysis (Macromysis) flexuosa O. F. Müller.
» » *neglecta* G. O. Sars.
» » *inermis* Rathke.

Already in the year 1860 has Van Beneden (3) published some biological observations on Mysids from the coast of Belgium. He found eggbearing females at all times of the year, even in the month of February, but most frequently in June and July, and he supposes that the fecundity is greater and the period of development shorter during the summer than during the winter time. He found only about 50 eggs in each female and assumes therefore that one female is capable of producing several broods of young. About the copulation he remarks that it takes place in the interior of the female. Della Valle (6) has (1887-89) described the fertilisation, deposition and cleavage of eggs in *Gammarus pulex* from Naples. Unfortunately this paper has not been accessible to me, but from a report of it in the Zoological Report 1889 p. 25 it appears that the deposition of eggs can take place only after a casting of the integument, because the oviducts only then have external openings. The fertilisation is external, the sperm being ejected upon the ventral surface of the female, round the terminations of the oviducts. Also in the related species *Gammarus pungens* M. Edw. Della Valle (6, 1893) has seen copulation and oviposition immediately after the casting of the skin of the female. He gives figures (Table 1 and 50, Fig. 1) of the different attitudes of the two sexes before and during copulation. Apstein (2) published in 1906 a detailed account of the life history of *Mysis mixta* Lillj. in the Baltic. By measuring a large material caught in the months February, May, August and November 1904 and 1905 he showed that this species is annual, the adult specimens from the preceding year all dying off before the summer is over. The young are born during the months February-August, but most of them do not reach maturity in the same year. Yet Apstein has found in August some few mature males and females of comparatively small size, which as he remarks p. 249 must be individuals early mature and born in the beginning of the year. From his tables of measurements it will be seen that also newly hatched young ones occur in the month of August; among these he probably includes young of the above named early born females. It therefore appears as if *Mysis mixta* produces at least two generations annually. In the year 1908 Haempel (11) published a paper on the reproduction and artificial raising of *Gammarus pulex* L and *Gammarus fluviatilis* R. These species breed during

all months of the year in Bavaria. He watched a number of them in aquaria and found that each female on an average produced 3 broods and that there was a space of 18-19 days between each oviposition, comprising "copulation" (8 days), casting of the female's cuticle and the oviposition (1 day) and finally, hatching of the young (9-10 days). The young ones reach maturity when about 3 months old, but never the less Haempel concludes as a result of his aquarium experiments, which at most gave abt. 15 young from each pair of gammarids in 4 months, that artificial rearing of *Gammarus pulex* as a fish food will not pay. — Embody (9, 1911-12) has investigated the biology of 4 species of amphipods from fresh waters in North America. Of these the largest species, *Gammarus limnaeus*, lived in a cold brook with an average temperature of abt. 9° C., the three others viz: *Gammarus fasciatus*, *Eucrangonyx gracilis* and *Hyalella knickerbockeri* in waters with average temperatures of 17 to 20° C. None of these amphipods breed during the whole year. the breeding periods of the four species ranging from January to September, April to November, January to November and April to September respectively. By keeping some of the amphipods in aquarium, the author found that each female produced several broods of eggs, viz: *Gammarus limnaeus* 2 broods, *Gammarus fasciatus* and *Hyalella* 3 broods; in the case of *Eucrangonyx gracilis*, however, no female produced more than a single brood of eggs. The space of time between two successive ovipositions was the same as between two successive moults in the female, and this space of time was reduced as the temperature increased. In *Gammarus limnaeus* this period varied from 26 to 38 days by temperatures ranging from 17° to 9° C., respectively; with the three remaining species this period varied from 10 to 19 days by temperatures ranging from 24,3° to 15,2° C. respectively. Based upon the counting of eggs in the females and upon the growth of the young in aquaria, Embody has calculated how many broods and successive generations one pair of amphipods can produce during the breeding period. The results he has obtained range between one generation comprising altogether 833 young *(Eucrangonyx gracilis)* and four generations comprising altogether 24000 young *(Gammarus fasciatus)*. These figures are, however, based upon very slight foundations. Later on I shall give this matter a further treatment.

A rather full account of the biology of the above named species *Hyalella knickerbockeri* has been published by H. H. Jackson (12, 1912). From a report of this paper (which has been inaccessible to me) by Frits Johansen ("The larger Freshwater Crustacea of Canada and Alaska". The Canadian Field-Naturalist. Vol. XXXIV, No. 7. Oct. 1920) it is seen that *Hyalella* in Wisconsin breeds throughout the year, but especially during the summer. Soon after copulation the eggs pass into the brood pouch of the female, but they take almost a month to hatch. There is a period varying from one to five weeks between each moulting.

In a paper on the reproduction and duration of life of amphipods from Tromsø, Norway, I. Sparre Schneider (23, 1891) indicates the breeding time of various amphipods as a comparatively short period of the year, mainly during summer and spring. According to the author's opinion the *Monoculodes borealis* Boeck breeds only once anually, and its duration of life is one year; furthermore he mentions some other amphipods, which he likewise assumes to be annual. Contrary hereto it is said that *Oedicerus lynceus* reaches an age of two years in analogy with

Arctia caja, which at Christiania is annual, but at Tromsø biennial. Finally there are a few species of amphipods said to be fullgrown only when reaching an age of 3 to 4 years. It is, however, inpossible to see how exhaustive the material has been upon which the author has founded these conclusions. *Gammarus locusta* is not mentioned at all.

In 1913 E. W. Sexton and Annie Matthews (22) have published some excellent observations upon the biology of *Gammarus chevreuxi* Sexton, a small brackish-water form resembling *Gammarus locusta* "more closely than any of the other species of the genus". It lives in the neighbourhood of Plymouth in ditches which are only in connection with the sea at the highest tides. The published observations are all made upon individuals kept in small jars and fed on plant food, partly fresh and partly in the form of detritus, and in these jars the animals appear to breed during the whole year. It must, however, be taken into account that the temperature in the jars during the winter was mostly of a considerable higher degree (10-16°) than the temperature in the free nature. As shown trough the experiments made by the authors, the temperature exerts an exeedingly great influence upon the conditions of life of the Gammarids in question. In the present instance care must, therefore, be shown in apprehending conclusions drawn from aquarium experiments as applicable to the conditions of free nature. The hatching lasts 11 to 14 days, and upon completion is immediately followed by a new oviposition. Between June the 4th 1911 and January 2nd 1913 five generations were bred, the space of time between one generation and the following being only about 50 days, and during the heat of summer this period ist most probably shorter. No definite information is given in reference to the duration of life. The young reached maturity when at least 36 days old, but the temperature of the water seems to exercise great influence upon this circumstance as well as upon the rate of moulting.

A very thorough description is given of the moulting and the mating of the two sexes. The male carries the female, sometimes for days running, before mating takes place. The male will, however, prefer to take a female bearing in its brood-pouch advanced eggs, which are at least 5 to 6 days old. The day after the last of the young has been extruded from the brood-pouch the moulting of the female takes place; about an hour later the male ejects its sperm into the pouch in the position described by Della Valle. When females were isolated during a moulting period, the moulting proceeded normally, but no deposition of eggs took place until a male within the course of three days was placed in the same aquarium. "If a male is kept away for four days or more after the female's moult, no mating occurs until the fourteenth day, i. e. until the next period begins, and such mating is preceded by a second moult". This agrees very well with the observations set forth by Embody (9, p. 11) in accordance with which a female *Gammarus limnaeus*, when isolated in an aquarium, moulted early the following morning, but failed to deposit its eggs during the next twenty-four hours. When at the end of this period a breeding male was admitted, oviposition followed shortly after and all the eggs developed normally and in due time.

Contrary to the above Clara Langenbek, who has described oviposition and fertilization in *Microdeutopus gryllotalpa* (14), states that an isolated female of

this species after moulting laid unfertilized eggs. The consecutive order, however, is normally as described in connection with the above species, viz: moulting, fertilization and oviposition.

Reibisch (20, 1905-06) has published some biological notes upon various species of amphipods in the North Sea. He is of the opinion that most of them breed only during the summer and autumn, and that only a few other species breed during the whole year. Unfortunately he does not give any definite proofs of these suggestions.

In 1910 Otterstrøm (18) examined the vertical wanderings of the *Mysis mixta* in the Baltic, and he came to the conclusion that this species, dwelling near the sea bottom during day-time will rise towards the surface of the sea at night. The depth to which the animals rise seems dependent on the light of the sky.

M. Samter and W. Weltner (21, 1904) have produced some biological facts with reference to three relict forms, viz: *Mysis relicta* Lovén, *Pallasiella quadrispinosa* G. O. Sars and *Pontoporeia affinis* Lindstrøm, found in the lakes of Northern Germany. The first named species breeds during the winter, December-March, but in the deep waters of the lake Dratzigsee this breeding period lasts considerably longer, extending from November till June, and in the following autumn, October-December, some of the females are able to produce another brood. This fact is explained by the authors as being due to the temperature conditions: they suggest that breeding is only possible in water of a temperature below 7° C. The cold region of water near the bottom of deep lakes permits therefore breeding, except during the hot summer months July-September. "The period of gestation" lasts 2-3 months, and the young reach maturity when about 9 to 10 months old. The duration of life is said to be $1^1/_3$ to $1^1/_2$ years.

The last named species — *Pontoporeia* — breeds too during the winter, December-April; the first produced batch of young are to be found in March, and accordingly the hatching period lasts about three months. All the adult individuals die off during the spring, but as to whether the species reaches an age of one or two years the authors are not able to give any information.

As to *Pallasiella,* this species is said to breed during the whole year, but most frequently during winter. From a short remark, page 685, we learn that the authors have examined 180 *Gammarus* (I suppose *Gammarus pulex*) from lakes in Northern Germany, and they have discovered that no egg- or young-bearing females were to be found during the winter, the breeding period being limited to the time from March till the end of August. As mentioned upon page 681 the authors have examined 5500 individuals of *Mysis relicta,* but as no further particulars with respect to the material employed have been published, it is not possible to decide whether the conclusions at which the authors have arrived are well founded or not.

S. Ekman too (8, 1920) came to the conclusion that *Mysis oculata relicta* (Lovén) in most of the Swedish lakes and in the Baltic breeds only during the winter (from late November till March), but in the lake of Vänern breeding occurs during the summer too. He supposes that *Mysis oculata* (Fabr.) in the arctic seas breeds during winter and spring and that maturity is not attained until the animals reach an age of two years, whereas *Mysis oculata relicta* in the Swedish lakes

breeds when only one year old. The author furthermore suggest that *Mysis oculata* in the arctic seas reaches an age of about three years, wheras *Mysis oculata relicta* at the most only becomes two years old. According to Ekman the breeding period of *Gammaracanthus loricatus* var. *lacustris* (Sars) extends through 4-5 months, beginning about the first days of August in the lake of Vänern, and about the last days of September in the lake of Vättern. The sexually mature individuals are said to be at least two years old. The form *Gammaracanthus loricatus* (Sabine) in the arctic sea breeds during the summer and autumn, and it is supposed to be at least three years old before maturity is reached.

Pontoporeia affinis Lindstr. breeds in the Swedish lakes, the Baltic and the arctic seas during the winter time only. It is assumed that this species reaches maturity at the age of two years, and that it reaches an age of at least $2^1/_2$ years.

Pallasea quadrispinosa Sars breeds in the lake of Vättern during the whole year, excepting only the months of July and August. It is supposed to reach an age of at least two years.

Unfortunately the material upon which the above stated conclusions are based is in most cases so slight, and has been gathered by various collectors at so irregular intervals of time that hardly any really trustworthy conclusions may be derived from it. Later on I shall return to a more detailed discussion of this matter.

Knut Dahl (5, 1915) has taken a great number of measurements of *Gammarus pulex* from various Norwegian lakes. Based upon such measurements in connection with investigations of the development of the sexual organs, he arrives at the conclusion that the species in question breeds only during a comparatively short period of the year. viz: from June till the beginning of August, and that each female breeds probably only once during this period; he also concludes that the young reach maturity in the course of about two years. The distribution of this species in Norway is very remarkable, being limited to the eastern part of the country.

From the above survey of the principal literature on the biology of Amphipods and Mysids will be noted how the life history of a single species may differ greatly according to the surrounding conditions. *Gammarus pulex* e. g. breeds during the whole year in the milder climate of Bavaria, but in the cold lakes of Norway only during a short period of the summer. While the young of this species in Bavaria reach maturity in the course of three months, upward of two years are required in Norway according to Dahl.

Seeing that the biology of a freshwater species as *Gammarus pulex* may vary to such an extent in two countries, situated within such short distances from Denmark, it appeared to me that an examination of the biology of the above named four species of the genera *Gammarus* and *Mysis* in the Danish seas would be of special interest.

The investigations have mostly been pursued in the Nyborg Fjord, where each of the above named four crustaceans are obtainable at all times of the year. Occasionally subjects have furthermore been collected from the Limfjord, the Bay of Kerteminde and the Svendborg Sound. The animals have mostly been caught from a small boat by means of a hand-net or a "gastropod seine", i. e. a bag of closely woven stuff attached to a beam, dragged by a small sailing vessel. This gear has

proved to be especially well adapted for catching such small crustaceans. When the dragging was completed, the contents of the seine were immediately washed out in a zinc tub containing clean salt water, out of which the crustaceans later on were fished by means of small flat hand-nets of silk gauze. When the contents of the tub had been left undisturbed for some time, most of the crustaceans and especially the Mysids would crowd around the sides of the tub, and from there it was easy to fish them out by means of the little hand net. Contrary hereto *Gammarus locusta* would often hide themselves amongst the fine algæ, which therefore had to be washed out in smaller vessels and thereupon looked over one by one in order to recover every one of the subjects.

The investigations on the biology of these animals have been carried on during the years 1916-19; they may be divided into, first: periodically repeated measurements of lenght; second: aquarium observations; and third: investigations on the size of production.

When collecting animals for measurement purposes, I had especially in view that the sample taken really might represent the stock in nature; as to the various difficulties in this respect, I may refer to the following chapters on the measurement investigations. Having collected a sufficiently large sample, the animals were all killed in 70 % alcohol, after which they were measured upon a glass plate provided with etched divisions in mm. All measurements were reckoned from the very foremost edge of the head or, as in the case of the Mysids, from the foremost edge of the eyes, to the hindmost edge of the uropods.

The aquarium observations were carried out in the twenty salt-water aquaria of the Danish Biological Station at Nyborg; ten of these aquaria were made of cement, the five having a capacity of 440 litres each and the remainder a capacity of 650 litres each. The other ten aquaria were made of glass with a capacity of 38 litres each. Most of the biological observations have been taken from the small glass aquaria, which contained water from the Nyborg Fjord, and which were permanently aerated by means of an air-pump, operated by electricity and working automatically. From the air-pump the air is lead to the aquaria through long iron tubes, from which branch tubes provided with screw taps were carried down into each separate aquarium. The branch tubes ended in canes, from which the air ascended in fine bubbles and thus oxidized the water. The advantage of this arrangement is that a renewal of the water in the aquaria becomes unnecessary, and at the same time the admittance of foreign substances, which might possibly disturb the experiments, is prevented. During summer the large cement aquaria were exposed to the open air, though covered by a lid. During winter, however, all the aquaria were brought under shelter in two wooden buildings, and when necessary the temperature in these buildings was raised by means of lamps to prevent the water in the aquaria from freezing.

The subjoined table of temperature will show how it was possible, by the means described, to maintain the temperature of the water in the aquaria in close conformity with the temperature of the surface water in the Nyborg Fjord. The figures comprise temperature measurements in degrees of Celsius, taken during the period $^{19}/_{6}$ 1917-$^{2}/_{7}$ 1918.

It appears from this table that the temperatures, as well in the aquaria as in the sea, vary greatly throughout the year; but the differences between the temperature in the water of the aquaria and that of the sea water, in which the animals subject to investigation live in nature, are too small to effect any influence whatever upon the results of the aquarium experiments, as the variations between the extreme aquarium temperatures quoted below and the simultaneous sea water temperatures average only $1{,}8^0$ C.

Date	$^{19}/_{6}$	$^{22}/_{6}$	$^{23}/_{6}$	$^{26}/_{6}$	$^{29}/_{6}$	$^{14}/_{7}$	$^{17}/_{7}$	$^{13}/_{8}$	$^{21}/_{8}$	$^{23}/_{8}$	$^{10}/_{9}$	$^{13}/_{9}$	$^{26}/_{9}$
Aquaria	$21_{,0}$-$24_{,0}$	$17_{,0}$-$18_{,0}$	$16_{,0}$-$17_{,0}$	$18_{,0}$-$20_{,0}$	$19_{,0}$-$20_{,0}$	$18_{,5}$-$19_{,0}$	$19_{,4}$-$19_{,6}$	$18_{,4}$-$18_{,6}$	$18_{,0}$	$19_{,8}$	$13_{,0}$-$14_{,0}$	$11_{,0}$-$12_{,0}$	$16_{,5}$
Surface water in Nyborg Fjord	$22_{,5}$	$18_{,0}$	$16_{,5}$	$17_{,5}$	$18_{,5}$	$18_{,5}$	$18_{,6}$	$19_{,0}$	$17_{,4}$	$19_{,0}$	$13_{,8}$	$13_{,6}$	$14_{,5}$

Date	$^{28}/_{9}$	$^{3}/_{10}$	$^{11}/_{10}$	$^{15}/_{10}$	$^{18}/_{10}$	$^{22}/_{10}$	$^{25}/_{10}$	$^{29}/_{10}$	$^{1}/_{11}$	$^{5}/_{11}$	$^{8}/_{11}$	$^{12}/_{11}$	$^{15}/_{11}$
Aquaria	$12_{,2}$	$13_{,0}$-$14_{,0}$	$7_{,0}$-$8_{,0}$	$7_{,4}$-$8_{,0}$	$8_{,0}$-$8_{,1}$	$7_{,3}$-$8_{,0}$	$6_{,8}$-$7_{,2}$	$4_{,2}$-$5_{,0}$	$5_{,4}$-$6_{,8}$	$5_{,8}$-$6_{,1}$	$5_{,8}$-$6_{,0}$	$5_{,1}$-$5_{,8}$	$5_{,2}$-$5_{,4}$
Surface water in Nyborg Fjord	$13_{,4}$	$13_{,4}$	$9_{,5}$	$9_{,4}$	$9_{,2}$	$9_{,8}$	$9_{,2}$	$6_{,8}$	$8_{,1}$	$7_{,2}$	$6_{,2}$	$7_{,1}$	$8_{,1}$

Date	$^{26}/_{11}$	$^{3}/_{12}$	$^{10}/_{12}$	$^{17}/_{12}$	$^{24}/_{12}$	$^{3}/_{1}$	$^{16}/_{1}$	$^{2}/_{2}$	$^{13}/_{2}$	$^{26}/_{2}$	$^{9}/_{3}$	$^{20}/_{3}$	$^{5}/_{4}$
Aquaria	$4_{,1}$-$5_{,2}$	$3_{,4}$-$4_{,2}$	$4_{,1}$-$5_{,0}$	$2_{,1}$-$4_{,0}$	$1_{,4}$-$2_{,3}$	$1_{,2}$-$1_{,4}$	$2_{,4}$-$3_{,2}$	$2_{,2}$-$3_{,4}$	$2_{,0}$-$2_{,3}$	$2_{,1}$-$2_{,4}$	$3_{,4}$-$4_{,4}$	$3_{,2}$-$4_{,1}$	$3_{,8}$-$4_{,3}$
Surface water in Nyborg Fjord	$6_{,4}$	$5_{,4}$	$5_{,0}$	$3_{,0}$	$2_{,1}$	$1_{,2}$	$0_{,0}$	$1_{,1}$	$1_{,2}$	$1_{,4}$	$3_{,2}$	$4_{,4}$	$5_{,1}$

Date	$^{16}/_{4}$	$^{19}/_{4}$	$^{24}/_{4}$	$^{30}/_{4}$	$^{1}/_{5}$	$^{4}/_{5}$	$^{9}/_{5}$	$^{14}/_{5}$	$^{23}/_{5}$	$^{10}/_{6}$	$^{20}/_{6}$	$^{26}/_{6}$	$^{2}/_{7}$
Aquaria	$8_{,0}$	$5_{,0}$-$6_{,4}$	$9_{,5}$-$10_{,5}$	$5_{,5}$-$6_{,0}$	$6_{,8}$-$7_{,8}$	$8_{,8}$-$10_{,6}$	$9_{,0}$-$13_{,0}$	$10_{,0}$-$12_{,0}$	$20_{,0}$	$15_{,0}$-$16_{,0}$	$16_{,0}$	$10_{,5}$-$12_{,0}$	$15_{,5}$-$16_{,5}$
Surface water in Nyborg Fjord	$8_{,0}$	$6_{,0}$	$8_{,4}$	$8_{,4}$	$11_{,6}$	$10_{,4}$	$12_{,4}$	$12_{,8}$	$18_{,0}$	$15_{,0}$	$16_{,0}$	$11_{,0}$	$17_{,0}$

Investigations upon the size of production have been carried out, partly by weighing the animals caught within a limited area of known size, and partly by means of feeding experiments in the large cement aquaria.

It is applicable to all the present investigations that they have been made occasionally in such spare-time, as my work on board the steamer of the Biological Station, where I acted as assistant to Dr. Petersen, would allow. Thus cruises lasting a week ore more, prevented me in giving constant attention to the aquaria, and naturally this impeded the aquaria experiments considerably. The lack of small aquaria was another obstacle, I having at my disposal only ten small glass aquaria in which numerous experiments on four different species of crustacea had to be carried out simultaneosly. I am, however, greatly indebted to the director of the Station, C. G. Joh. Petersen, Ph. D., L. L. D., for the interest he has constantly shown in my work; without this interest I should never have been able to carry through the present investigations. At the same time I furthermore take this opportunity of thanking Mr. K. Stephensen of the Zoological Museum at Copenhagen, for the valuable assistance he has afforded me in the determination of various species of crustacea.

Gammarus locusta L.

The adult *Gammarus locusta* found in the Nyborg Fjord agrees essentially with the form described and drawn by Sars (An Account of the Crustacea of Norway, Amphipoda, 1895, p. 499; Pl. 1 and 176). Contrary hereto the third uropod of the young agrees more particularly to that of *Gammarus marinus* Leach, which in the above quoted work by Sars is shown in Pl. 175. Furthermore the arrangement of the hairs and several other characters vary greatly, not alone during the period of growth, but also in the adults; several of the individuals found in the Nyborg Fjord resemble the *Gammarus locusta* from the Randers Fjord as described by Stephensen (Vid. Medd. Bd. 68, 1917; p. 38). *Gammarus pulex* de Geer I have only found once in the Nyborg Fjord in the vicinity of a small river, but of other amphipods living freely in the sea, there is a great abundance. Amongst others which I have caught simultaneously with *Gammarus locusta* in the Nyborg Fjord are the following species: *Calliopius Rathkei* (Zadd.), *Microdeutopus danmoniensis* Sp. Bate, *Autonoë longipes* (Lilljeborg), *Microdeutopus gryllotalpa* Costa, *Apherusa bispinosa* (Sp. Bate), *Dexamine spinosa* (Mont.), *Amathilla angulosa* (Rtk.), *Amathilla homari* (Fabr.), *Amphithoë rubricata* (Mont.), *Gammaropsis melanops* G. O. Sars, *Ischyrocerus angvipes* Krøyer. There can be no doubt but that *Gammarus locusta* is the amphipod species of the greatest importance to the ecology of the Fjord; it is the biggest, and I believe the most frequent species too. The adult specimens constitute a much sought for food of the cod, eel and viviparous blenny, and the young are eaten with preference by the small fishes of the plant belt: goby, stickleback, fifteen-spined stickleback, needle-fish, etc.

Gammarus locusta of the Nyborg Fjord lives in the *Zostera*-belt, especially in shallow water near the coast. It likes to hide among stones, in living and dead weed, and — most commonly — among clusters of mussels *(Mytilus edulis)* on the sea bottom, on poles, piers and the like. Its food consists of plants, partly fresh and partly in the form of detritus (the latter especially preferred by the young). Animal remains e. g. of smaller crustacea are only seldom found in their intestines (see Blegvad (4), 1914, p. 70).

Measurement Investigations.

The measurement investigations of *Gammarus locusta* have been carried out during the years 1916—1918. The investigations include 43 measurements of 24590 individuals in all, collected from the Nyborg Fjord alone. The first measurements taken were made upon the material gathered from the *Mytilus* clusters, these being shaken in clean water, whereby the gammarids located among the shells or the byssus-threads were shaken off into the water, from where they

could easily be sifted. It soon became evident that these gammarids living among *Mytilus* were not serviceable as perfectly valid representatives of the stock of this species in the Nyborg Fjord, consisting mainly of larger individuals. In taking a sample of gammarids from algæ in shallow wather, it appeared that this sample contained mostly smaller individuals, newly hatched young as well as more advanced but not yet fully developed gammarids. On account hereof it became necessary, when wanting a sample of gammarids for measurement purposes, to take specimens from shallow water as well as from *Mytilus*. Having examined gammarids from various places in the Nyborg Fjord, it was decided to obtain the samples partly from a certain place on the outside of the pier in the Nyborg harbour and partly from *Zostera* and algæ in the shallow wather near the anchorage of the Biological Station. The samples taken from these places appeared to be good representatives of the entire stock of *Gammarus locusta* in the Nyborg Fjord. In order to obtain samples, which might allow a mutual comparison, about 12 litres or 11,5 kg *Mytilus*, covering an area of abt. $1^1/_2$ sq. metre was taken each time, and from this the gammarids contained therein were removed. This manner of proceeding has been employed from May 1916 and during the whole time these measurements have been carried out.

It soon became apparent from these measurements that the size of the gammarids and the composition of the stock was subject to considerable variations from month to month, whereas the variations as compared between one year and the corresponding period in the followning year were very slight. The tables 1 and 2 at the end of this paper contain therefore only 12 of the most complete and representative measurements, these forming a sufficiently distinct picture of the changes, which take place during the different times of the year. Distinctions have been made between males (♂), females with eggs or young in their incubatory pouch (in the tables indicated in column marked „♀ with eggs"), females without eggs or young in the incubatory pouch (in the tables indicated in column marked „♀ without eggs"), and finally young. The adult males are easily distinguished from the females by the great difference in the size of the chelæ of their first and second gnathopods, these being in the female of equal size. On the other hand the young, which measure less than 10 mm in length, cannot be separated in males and females, except in cases where the females carry eggs. Such egg-bearing females are very easily distinguished from the others on account of their comparatively broad body distended by the eggs, which may be seen as a blackish-blue mass through the thin lamellæ of the incubatory pouch. While the egg-bearing females thus as a rule may be picked out from the entire material, this will apply only to the largest of the males; the smaller individuals it is necessary to separate by aid of a binocular microscope. This separation is often facilitated by the fact that the ovaries of the females, which are in a more advanced stage towards maturity, are faintly seen along the back of the animal as two broad dark stripes, in which the eggs at times may be seen distinctly separated from each other. The eggs in the ovaries are brownish purple in colour and contain large, colourless oil-globules. As the females in most cases may be sorted out from the stock in much smaller size than the males, it is easily understood that there will usually be a greater number of individuals in the column „♀" than in the column

„♂", while at the same time the column „young" will comprise a greater number of males than females. All individuals, which could not be determined with certaninty as to their being males or females, have been put down as „young". As to how many of the „young" may be sorted out as true males or females will always be a matter of judgement, and it must therefore be borne in mind during the following that the limit between the young and the smallest male and female individuals is no fixed and definitely determined line; caution must be shown in drawing comparisons between the amount of „young" in the measurement-lists.

In figs. 1 and 2 I have given a graphical view of the results of measurements during a single year. The divisions of the ordinates represent the number of individuals, while the divisions of the abscissæ indicate their lengths. In order to facilitate comparisons of the curves, the scale of classification is the same everywhere in fig. 1. As mentioned above each of these measurements comprises the stock of gammarids from $11^1/_2$ kilos *Mytilus*, collected from a certain place at the pier of the Nyborg harbour. To save space the scale of classification of the ordinates in fig. 2 is only half of that in fig. 1, excepting, however, the three measurements from November and February, where the same scale as in fig. 1 is used. Opposite each measurement is stated the total number of individuals measured, their average length and the average length and number in per cent of the separate groups, each of which is represented in the measurements by a curve.

The measurements of gammarids from *Mytilus* on April 7th 1916 show that young are completely absent. The whole stock comprises big gammarids, which are fully engaged in breeding, no less than 71 of 75 females having eggs or young in their pouch. Unfortunately a contemporary measuring of the stock of gammarids collected from algæ was not taken; but from measurements taken in April 1917 and 1918 (see e. g. table 2) it was seen that already at this time of the year an extensive group of newly hatched young were to be found among algæ. At this period the first young accordingly make their appearance, whereas among *Mytilus* only adult gammarids are to be found as yet. Immediately upon being hatched the young seek out among the algæ in the shallow and sunny waters near the shore.

The measurement curves show that in the month of May a large group of young has appeared among *Mytilus*, but it will be noted that the newly hatched young — measuring about $1^1/_2$ mm when emerging from the brood-pouch — are most particularly to be found among algæ, and the more advanced among *Mytilus*. In the sample from *Mytilus* 47 pairs were in the „riding-position" (which preceeds the mating, see below p. 31), while in the sample from algæ there were 37 pairs. Of adult females without eggs or young in their brood-pouches there were only 6 in the sample from *Mytilus* and 11 in the sample from algæ, and these were all newly spent individuals; this was apparent from the large and slack, but empty, lamellæ of the pouch; thus the breeding is still in full activity. The average size of the males has increased, whereas that of the female with eggs or young in the incubatory pouch has decreased, especially in the sample from algæ. The sole explanation of this fact is that a numher of the young, which in April were still immature, have now reached maturity and breed when of a size inferior to that of the older females. Accordingly the curve of the young proceeds evenly into

the curve of the breeding females. The general appearance of the smallest breeding females, too, imply that they are considerably younger than the other breeding females, their colour being much brighter and more transparent. According to Tait (25) the body colour af amphipods is mainly affected by the colour of the blood.

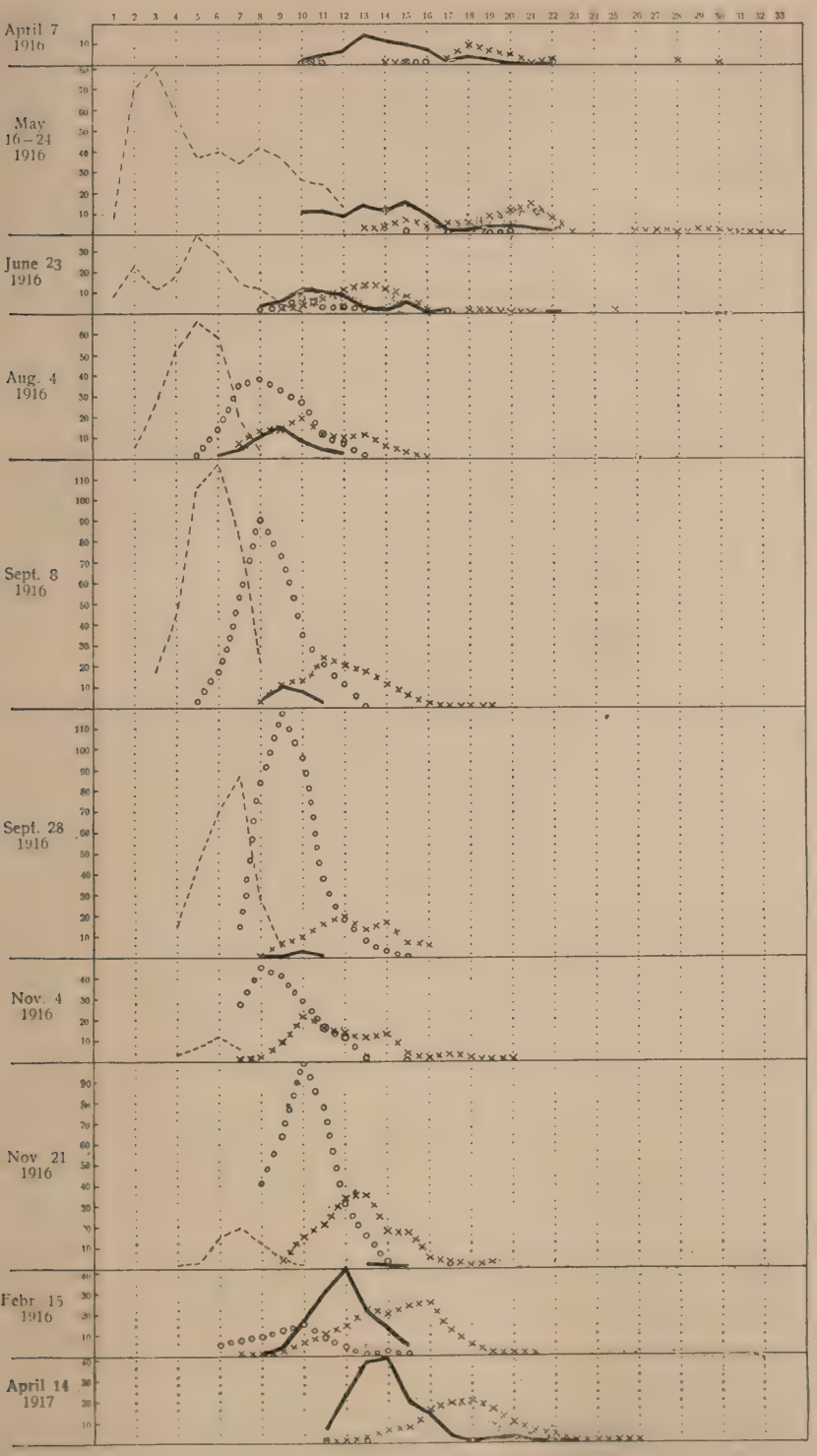
In the samples from the month of June 1916, all the curves exhibit a decrease in the size of the gammarids, especially in the case of the males, the average size of which, in the course of a month, has decreased 5,6 and 6,6 mm in the two samples from *Mytilus* and algæ respectively. This is due to the dying off of the largest individuals; as will easily be seen from the curves, the group of large males — 15 to 33 mm long — and females — 17 to 22 mm long — found in the May samples, have almost entirely disappeared in the June samples. As these large gammarids are nowhere to be found in numbers in the Nyborg Fjord, they must have died off. That the mortality, as indicatet by the curves, is the greatest among the males, is a fact which we will find affirmed later on by the aquarium observations. The curve of the breeding females too is, in the June sample, situated far more to the left than the corresponding curve in May; this is caused, besides by the dying off of the old individuals, by the constantly increasing supply of quite small and young females, which have just reached maturity. As will be seen from the June sample in Fig. 1, the curve indicating females with eggs or young is doublecrested; this might imply that it contains partly a wintered stock, which groups itself about 15 mm, and partly a stock of more recently born individuals with lengths averaging about 11 mm. In accordance herewith the last named individuals were of a far more light colour than the first named; the smallest breeding females measured only 8 mm in length, the largest 22 mm. Of the 57 breeding females 8 — all large, apparently wintered individuales — had young in their pouch, the rest carrying eggs; 21 males each carried a female in the „riding-position"; several of these females were not yet mature, having small, undeveloped incubatory lamellæ; but the well developed ovaries, the eggs of which could already be faintly seen through the dorsal plates, indicated that they would soon become ripe. — The group „females without eggs or young in the incubatory pouch" comprises almost exclusively immature females, and only a few spent individuals. A very large group of young now forms the main portion (81%) of the stock among algæ, and it consists of newly hatched young. On the other hand the group of young from *Mytilus* comprises, besides a less numerous group of newly-hatched young, a larger group of more advanced but not yet mature young; the curve of this group passes without interruption into the curves of the adult individuals.

During the month of July 1916 no measurements have been taken, but samples from July 1917 (tables 1 and 2) and 1918 show that in the course of this month, the last wintered gammarids die off. This is clearly evident from the fact that the smallest individuals in the april sample 1917 (see fig. 1) measured 11 mm in length; as the increase in size of the slowest growing group of the wintering gammarids viz: females with eggs, during the two months from February 15th till April 14th 1917 was more than 2 mm (2,13 mm, see fig. 1) the above named individuals measuring 11 mm in April must be supposed to have attained a length

Fig. 1. Measurements of Gammarus locusta from Mytilus.

Nyborg Fjord, April 1916 – April 1917.

The ordinates are number of individuals, the abscissæ their lengths in mm.



Total number	♂		♀ with eggs or young		♀ without eggs or young		young	
	G.	%	G	%	G.	%	G.	%
109	19,59		14,45		13,00			
G. 16,00		31		65		4		
666.	20,18		14,19		17,67		5,66	
G 8,94		13		15		1		71
305.	13,57		11,65		10,71		4,85	
G 8,57		22		18		7		53
546.	10,51		9,66		8,34		4,95	
G 7,40		17		9		31		43
828.	11,89		9,85		8,46		5,69	
G 7,67		13		3		36		48
732.	12,32		9,87		9,45		6,34	
G 8,77		12		1		52		35
299	11,93				9,35		5,75	
G 9,70		33				57		10
555.	12,80		13,—		10,20		7,02	
G 10,65		28		1		60		11
345	14,14		11,80		9,42			
G 12,38		42		39		19		
274.	17,75		14,03		14,00			
G 15,92		41		58		1		

--- Young

xxx ♂

——— ♀ with eggs or young in the incubatory pouch

ooo ♀ without „ „ „ „ „ „

G = Average size in mm.

% = Number of individuals in each group, expressed in percentage of the entire stock.

of at least 14 mm in July. Probably even this figure is too low, the growth of the gammarids being considerably quicker during the summer than during the winter (see aquarium observations p. 28). However, only 5 individuals of the 575 caught in July 1917 and 1918 had a length of more than 14 mm, and these may accordingly belong to the wintered stock; the remaining gammarids are at most only a few months old.

In the samples from August 1916 there remains only such small gammarids, which according to the calculations just mentioned cannot belong to the wintered stock; consequently they must all have been born during the year 1916. A great deal of the females are still breeding, and the average length of the breeding females has decreased further viz: to $9{,}_{06}$ and $8{,}_{13}$ mm in the sample from *Mytilus* and from algæ respectively. The smallest egg-bearing females measure now only 6 mm in length. The group „females without eggs or young", which was previously of inferior significance, is now extensive, comprising mainly young females, which are on the point of becoming mature; the incubatory lamellæ are not yet fully developed, but the ovaries are more or less visible as two dark stripes along the body. As usual the newly-hatched young are particularly found among algæ, the more advanced ones among *Mytilus*.

In the beginning of September the picture is about the same, but, whereas the group „females with eggs or young" till now has been most numerously represented in the samples from *Mytilus*, the greatest percentage of breeding females is now found among algæ. The average size is about the same; 31 pairs are in the „riding-position". In the sample from algæ the column „females without eggs or young" comprises exclusively females, which are nearly mature, but which have not yet been breeding; in the sample from *Mytilus* only a few spent females remain among the largest individuals. Among *Mytilus* no newly-hatched young are to be found at all, whereas a large group of these still occurs among algæ.

In the end of September the breeding activity has decreased considerably. Among *Mytilus* the breeding females constitute only 1 per cent of the stock, among algæ there are still some of this class, but considerably fewer than in the beginning of the month. The breeding period is obviously approaching its termination. The percentage of females without eggs has likewise increased considerably, and an examination of the ovaries and incubatory lamellæ of such females showed they were so far behind in development, even in the largest individuals, which are much larger than the breeding females, that they must be supposed not to reach maturity before the winter; in the sample from *Mytilus* the group „females without eggs" constitute more than half of the total stock; at the same time the group of young has decreaced in number, but increased in size.

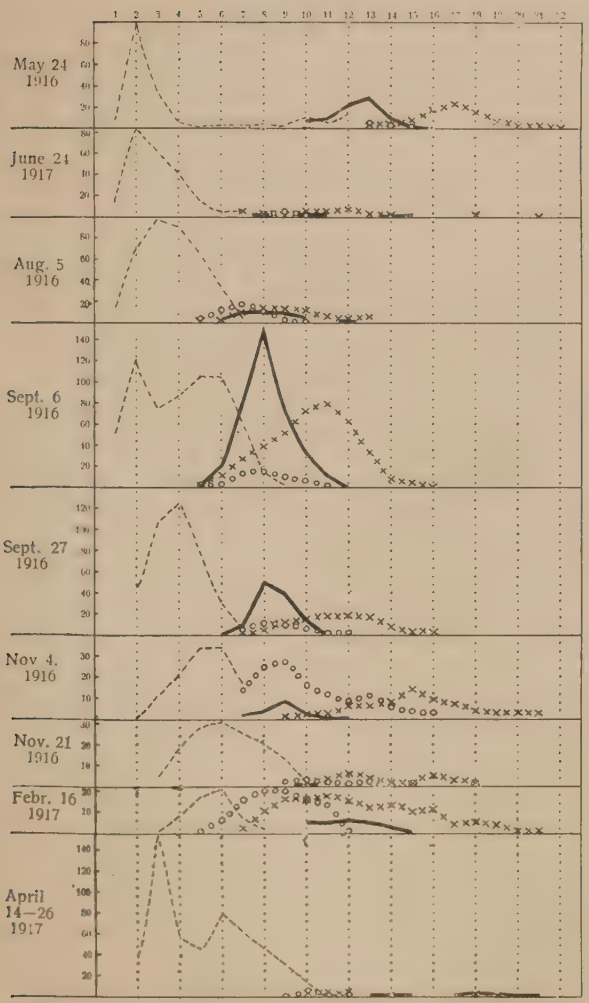
As the sample from October 1917 shows (tables 1 and 2) the breeding activity has almost ceased during this month; only among algæ a few breeding females are still to be found.

On November the 4th 1916 no more breeding females occur among *Mytilus*, and among algæ there are only 6 per cent. Of newly hatched young very few are found among algæ and none among *Mytilus*. The breeding period has practically reached its termination, and by and by the gammarids seek from the algæ into the clusters of *Mytilus* or burrow themselves among dead weed for wintering.

Fig. 2. Measurements of Gammarus locusta from Algæ.

Nyborg Fjord, May 1916–April 1917.

The ordinates are number of individuals, the abscissæ their lengths in m. m.



Total number	♂		♀ with eggs or young		♀ without eggs or young		young	
	G	%	G	%	G	%	G	%
375	16,81		12,51		13,61		1,00	
G 9,17		22		24		3		51
286	11,14		12,17		8,91		3,01	
G 4,53		13		2		4		81
533	9,12		8,13		7,00		2,—	
G 4,99		12		7		9		72
1444	10,24		8,15		8,—		4,17	
G 6,99		27		26		3		44
624	11,31		8,51		8,83		4,01	
G 6,29		15		19,5		5,5		60
334	15,20		9,00		10,05		5,19	
G. 9,33		21		6		38		35
187	13,68		10,00		11,40		6,28	
G 7,74		15		1		6		78
311	12,41		11,96		8,69		5,—	
G 10,04		41		6		30		29
573	15,24		17,58		10,75		5,21	
G 5,87		3		2		1,5		93,5

– – – Young.

××× ♂

▬▬ ♀ with eggs or young in the incubatory pouch

o o o ♀ without „ „ „ „ „ „

G = Average size in mm.

% = Number of individuals in each group, expressed in percentage of the entire stock.

That the breeding season is now at an end is furthermore seen from the fact that the stock as a whole begins to increase in length; while the average size of the stock during the whole summer was about the same, owing to the constant supply of young, or even decreased, because the large gammarids gradually died off, it

now increases evenly during the winter. (The sample from algæ November 21st 1916 exhibits, it is true, a decline, but as only 187 individuals have been measured at this time, this sample may not be considered perfectly trustworthy, particularly as the average size 6,02 mm of a sample from algæ November 20th 1917 shows an incline of 3,68 mm in comparison with average size 2,34 mm of a sample from algæ October 19th 1917).

On November 21st 1916 eggs have been found in the brood-pouches of 4 females among *Mytilus* (1 per cent of the stock) and of 1 female among algæ. On the other hand no newly-hatched young were found, neither among *Mytilus* nor among algæ.

During December and the beginning of January 1917 no measurements have been taken, but from the measurements of January 21st 1918 (tables 1 and 2) it will be noted that no newly-born young have as yet appeared; but a few of the largest females, especially among *Mytilus*, have now eggs in the brood-pouch, these females constituting 3 per cent of the stock from algæ and 24 per cent of the stock from *Mytilus*. An examination of these eggs showed that none of them contained embryos; they were accordingly comparatively newly laid.

The measurement curves from February 15th and 16th 1917 exhibit a large group of breeding females from *Mytilus*, and a smaller one from algæ. The average size of these breeding females is now close to 12 mm; in the sample from January 1918 it was 11,75 mm; as will be seen from figs. 1 and 2 the average size of the breeding females did not reach 10 mm during the time from August till late November (seen apart from the sample of November 21st 1916, where the number of breeding females is too small to offer any reliable results). During the winter months a considerable growth has accordingly taken place, not alone with respect to the young, but also with respect to the adult gammarids. Among *Mytilus* the group of young has totally disappeared, and among algæ where this group usually is by far the largest, it has diminished as to represent only one fifth of the entire stock. The fact that its average size at the same time has decreased since November 21st, is due to the limit between young, and immature males and females, which is as mentioned above very difficult to determine exactly, being carried further down in the measurement from February than in that from November. As will be seen the average size of the total stock has increased with 2,3 mm during these three months. Newly-hatched gammarids do not yet occur. An examination of the incubatory pouches of 45 of the breeding females showed that in 43 individuals they contained eggs; only one of these individuals had eggs with distinctly developed embryos, the remaining 42 having comparatively undeveloped eggs, which were mostly in the stages of cleavage. Only two females had newly-hatched young in their pouches.

During March 1917 no samples have been collected, but from the samples of 1918 (tables 1 and 2) it will appear that during this month there are still very few young at hand, although now nearly half of the wintered females have eggs or young in their brood-pouches. As will be seen later on, this agrees very well with the fact revealed by the aquarium observations, that the hatching of the young in the cold months of January-March lasts about one month or double the time required during the warm summer months.

During the month of April, however, the young appear in earnest, but for the present only among algæ, as will be seen from the curves for April 1917; they occur here in such numbers that they constitute 93,5 per cent of the entire stock. The adult gammarids hide themselves mostly among the *Mytilus* clusters; they have now reached the same size which their ancestors — the wintered stock — had at the same time in the preceding year, and they are all sexually mature; the three females without eggs in the sample from *Mytilus* April 14th 1917 (table 1) were all spent females. (In fig. 2 the 3 largest males measuring 27-28 mm in length have been omitted to save space).

Measurements from other years, some of which have been included in the tables 1 and 2, are only repetitions of the same cycle of life as described above, viz: during each summer the wintered stock will die off; the young, which in the meantime have become sexually mature, will breed during the whole summer until the month of October; during the following 4 winter months no breeding takes place, whereas the gammarids increase considerably in size; from the month of February, however, the wintered stock will resume breeding again and proceed until the whole stock has died off during the months of June and July. *Gammarus locusta* is thus an annual animal and its breeding period lasts from February till the first part of October.

In the different years only the growth seems to be subject to variations. Thus the measurements from *Mytilus* taken in the year 1918 indicate that the wintered stock of that year did not reach the size, the wintered stock had at the corresponding time in the years 1916 and 1917 (see table 1). This fact is presumably due to the temperature conditions of the sea water, which, as will be seen later on, exert a great influence upon the growth of the gammarids.

Measurements of *Gammarus locusta* from other waters than the Nyborg Fjord (The Isefjord, Svendborg Sound, the Limfjord) have been carried out upon samples collected from *Zostera* and algæ in shallow water. The samples have not been gathered at regular intervals, and they comprise altogether only 1370 individuals; yet the measurements on hand agree very well with the measurements obtained from the Nyborg Fjord. From the month of May, when the first measurements were taken, and till the first days of October, when the measurements were concluded, a large group of young was found, and the breeding period seems to terminate during the month of October, as on the 7th October 1917 not a single female carrying eggs or young was found in a sample, which was then taken from the Nykøbing Bay, Mors (Limfjord). According to a measurement from the same place taken on September 11th 1916, the gammarids become somewhat larger in the Limfjord than in the Nyborg Fjord. Upon comparing the average size of males and females with eggs, which in the above mentioned sample from the Limfjord amounts to 12,48 and 10,65 mm respectively, with the corresponding sizes in the sample from the Nyborg Fjord taken on September 6th 1916 (Fig. 2), it will be noted that the gammarids from the Limfjord are on an average more than 2 mm larger than the Nyborg gammarids. Otherwise the life history of *Gammarus locusta* seems to be the same everywhere in the Danish seas.

The measurement investigations cannot, however, give any definite answer to the following questions: 1) How many generations may be produced

during a single year? 2) How many broods may be produced by a single female? and finally 3) What is the rate of growth? From the aquarium observations described in the following, valuable information with respect to these questions are, however, obtained.

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2. Aquarium Observations.

The present observations have all been made in the aquaria of the Biological Station mentioned above. In order to afford as natural conditions as possible for the gammarids, a number of live *Mytilus* and fresh algæ were often introduced into the aquaria, but in some cases no extra food whatever was given, for special reasons which shall be explained later. Generally the gammarids were fed once a week with *Mytilus* opened by cutting the adductor muscles with a knife and thereupon given to the crustaceans. By this manner of proceeding the mussel was not killed immediately and would keep fresh for some days, even in the hot summer time. As a rule, however, the gammarids devoured in the course of an amazingly short time the soft parts of the mussel, leaving only the shells and the byssus-threads. Altogether *Gammarus locusta* turned out to be an animal well adapted to aquarium studies; in most cases the growth was rapid and the power of mutiplication large in the aquaria.

As will be remembered, the measurement investigations have made it evident that during the spring and summer we have to deal with two different stocks of gammarids, firstly the wintered, large gammarids, and secondly their offspring, the smaller and more bright-coloured gammarids, which breed when of a size far inferior to that of the older, wintered gammarids. As a convenience I have in the following employed the terms „winter-stock" and „summer-stock" to designate these two stocks; the first named term comprises all the gammarids born during the previous year and which have survived the winter; the last named term comprises all the gammarids born during spring and summer of the current year, having accordingly not yet wintered. As will be seen later on, it could in some cases be difficult to determine whether a certain individual belonged to the winter- or summer-stock; but as a rule this distinction was very easily carried out when consideration was taken to the size, stage of maturity and colour of the gammarids in question.

A general view of the progress of the aquarium observations will appear from the description given below*); the different „experiments" have been arranged in two groups, dealing with the winter-stock and the summer-stock respectively.

A. Winter-stock.

Experiment I.

The object of the present aquarium experiment was to ascertain the number of times a single female can breed. It was proved that a *Gammarus locusta*

*) A more detailed account is published in the Danish edition of this paper p. 6-25.

female, measuring about 14 mm in length*) and placed in the aquarium on April 30th 1917, produced eggs at least eight times; the first time was on May 5th and the last on September 15th 1917, i. e. in the course of 133 days. The eggs were, however, not laid at regular intervals, there being between the first and the second brood a space of 25 days, between the second and third and between the third and fourth 12 days, between fourth and fifth 16 days, between fifth and sixth 21 days, between sixth and seventh 30 days and between seventh and eighth 17 days; it is, however, possible that an unremarked oviposition may have taken place between sixth and seventh broods. Most often the eggs died and in the course of a few days fell out of the mother animal's incubatory pouch, which in connection with the unusually long periods — as will be seen later on — between the ovipositions at the end of the months of June and July, is suggestive of the fact that the breeding conditions in the aquarium were not quite satisfactory, though care was taken that there were full-grown males present. Feeding was effected twice a week with mussels, and fresh algæ were at all times to be found in the aquarium. Subsequent to September 15th no new ovipositions were observed, and upon March 9th 1918 the female, now measuring 24 mm, was found dead, after having lived in the aquarium for more than 10 months.

The long life of this gammarid female, which is unusual for a wintered individual, gives occasion to enquire, if it has not been an exceptional rapidly growing individual of the summer-stock, born early in the year. This being, however, of minor importance in the present connection, I have concluded that this experiment ought nevertheless to be mentioned in the chapter regarding the winter-stock, to which stock the female in question judging by its size, must be classed.

Experiment II.

This aquarium experiment comprises a stock of about 60 *Gammarus locusta* females of the winter-stock, and which were kept breeding in glass aquaria from April 17th 1917 until August 20th 1917, at which date they had all gradually died off. In the period mentioned they were fed with mussels and algæ. With exception of the month of May, when I was absent from the Station and therefore could not attend to the aquaria, a continuous control was carried out to ascertain how often the gammarids bred; the manner of proceeding employed here was to isolate the females in several separate aquaria, according to how many broods of eggs they had laid; as soon as a female had got a new brood of eggs in its pouch, it was transferred to the next aquarium and the date noted down. Furthermore observations were made in reference to the duration of the period of incubation as well as to the rate of mortality among the stock.

It was observed that all the gammarids continued to breed, the one breeding following immediately upon the other, until they died off; the longest living gammarid female had at least 7 broods of eggs, probably 8, as the breeding conditions could not be controlled during the month of May. Upon being placed

*) It must be noted that where the figures refer to live gammarids the figures of size can only be approximate; the limit of errors can be set at about 1 mm.

in the aquarium all of the 60 females carried eggs or young in their incubatory pouches; reckoning this brood as the first brood, the gammarids produced eggs in the following succession:

	June.			July.			Aug.	
	1–10	11–20	21–30	1–10	11–20	21–30	1–10	11–20
Eggs 2nd time	*) 42	9						
» 3rd »	7	14	3	1				
» 4th »		4		5		1		
» 5th »					1	2	1	
» 6th »						1	1	
» 7th »								1

*) Of these the 12 individuals were killed for examination on June 1st.

The figures signify the number of females, which got new eggs in their incubatory pouch within the period stated above the column in question.

Of the 60 egg- and young-bearing gammarid females, introduced into the aquarium on April 17th, there were thus 51 individuals (or 85%) which had eggs for at least the second time in the period June 1st till 19th. Of these the 12 were killed on June 1st, and of the remaining 39 individuals, the 25 (or 64%) had eggs for at least the third time between June 1st and July 3rd; of these the 10 (or 40%) had eggs at least the fourth time between June 18th and July 23rd; on July 17th, 23rd and August 7th four of these (or again 40%) had eggs for at least the fifth time; 2 of them had thereafter eggs for at least the 6th time on July 30th and August 4th, and finally the last surviving female had eggs for at least the seventh time on August 15th.

The rate of mortality thus increased considerably during the summer; it was very low in the months of April and May, when only 4 of the 60 females died off, but in the month of June it increased greatly, no less than 36 individuals of the 44 (12 having been killed in alcohol June 1st) dying off; in the month of July 4 individuals died, and the last 4 died in August. The most of the females died with eggs in their incubatory pouches, but these eggs were mostly without embryo. Among the 44 gammarid females which died in the aquarium after June 1st, there were 28 carrying eggs, and only in three of these the eggs contained embryo or had commenced cleavage. The others must therefore either have contained quite newly laid eggs or eggs, which had not been fertilized. There is certainly no doubt but that gammarids are very sensitive after a moult, i. e. in this case immediately after having received eggs in their incubatory pouches, but on the other hand females with few and undeveloped eggs were so often found that it shows, many of them are not fertilized in the aquaria, and especially amongst these the rate of mortality seems to be great. Among the females found dead, and which contained eggs without embryo in their incubatory pouch, the eggs in the following individuals were counted:

Length in cm.	Number of eggs without embryo.
13	10
14	35, 30
15	41, 39, 34, 7
16	44, 40, 30, 4
17	62, 62
20	35, 80

Upon comparison with individuals from free nature (see page 40) it is obvious that the figures stated here are on an average very low, in some cases even so low, that only the dying off of the eggs and their falling out of the incubatory pouches subsequent hereto can explain them.

Whith reference to the duration of the period of incubation*) this experiment submits the following information:

8 gammarids, empty on June 1st, got eggs a second time between June 3rd and 6th; in the course of 8 days the eggs contained distinct embryos and 3 of the gammarids were empty on June 14th, 3 on June 16th and 1 on June 18th; 1 individual died 10 days after the eggs were laid; it contained young which had quite recently broken their eggshells. In these instances the whole period of incubation, from the laying of the eggs till the young emerge from their mother's incubatory pouch, has lasted about 11 to 12 days. In the case of 3 ♀, which got eggs the third time between June 14th and 18th, the 2 had on June 23rd eggs with embryos and the 1 had young, and on June 26th they were all 3 empty, the period of incubation having lasted at the highest 12 days. 2 ♀ which got eggs the third time about June 5th, had young about 9 days later and were empty on June 16th, the period of incubation lasting about 11 days. 2 other ♀ which got eggs the third time on June 6th, contained eggs with embryos on June 14th, young on June 18th and became empty on June 18th and 19th, the period of incubation lasting 12 and 13 days respectively. 3 gammarids which got eggs the fourth time on July 2nd, 5th and 10th respectively, contained eggs with embryo in the course of 8 days and then each of them went into „riding-position" with a ♂. In the course of further 1 to 3 days they had young in their incubatory pouches, and after the elapse of 15, 18 and 15 days respectively from the fourth oviposition, they got eggs the fifth time. In this new brood of eggs embryos were observed 5 days later, and the young appeared in the course of 9 days; already 11 and 13 days respectively after getting eggs the fifth time, 2 of the individuals got eggs the sixth time, and 16 days later one of these got eggs the seventh time.

It can be said that during the months of June-August the gammarids as a whole got on an average a new brood of eggs every fortnight. On the other hand numerous instances show that the gammarids often lose their eggs in the incubatory pouch after a very shorth time, and this can only be explained by the fact that they have not been fertilized. Thus 3 gammarids, all containing newly laid eggs the second time on June 14th, were already quite empty before June 19th, i. e. 5 days later. In such cases the aquarium observations show that the females had empty incubatory pouches a comparatively long time before they could get eggs again, which is only reasonable, whereas the rule is that the copulation and the laying of new eggs succeeded immediately upon the hatching of the young; it is in the foregoing stated that the rate of mortality amongst such individuals seems to be much greater than amongst the normally breeding females.

If the main result of experiment II is to be expressed in a few words, they would be the following: A numerous stock of wintered gammarids in small glass

*) By this is to be understood the period, which elapses between the laying of the eggs and the time when the young leave the mother animal's incubatory pouch.

aquaria have bred continually from the time they were placed in the aquaria with eggs or young in their incubatory pouches, about the middle of April, and until they had all gradually died off before August 20th of the same year; the gammarids which lived the longest got also eggs most often, but the rate of mortality increased considerably during the summer. The period of incubation during the months June-August lasts 11 to 12 days, and a new mating usually takes place a few days afterwards; on an average each individual got new eggs every fortnight. The female which lived the longest had thus between June 1st and August 15th 6 broods of eggs, viz. one brood about the 1st and the 15th of each month.

Experiment III.

This aquarium experiment comprises 4 females of the winter-stock. Each individual was kept in a separate aquarium from early spring 1918 until they all died off in the course of the summer of the same year, and the experiment was made in order to investigate how long the period of incubation lasted during the cold season. It was observed here that during early spring the period of incubation was twice as long as during the summer, and that it decreased as the summer approached. The period of incubation for eggs laid on March 20th lasted 25 days, for eggs laid on April 19th, 21 days, which was the same as for eggs laid on April 29th. The period of incubation for a brood of eggs laid on April 24th was even 27 days, but for eggs that were laid as late as May 21st the period of incubation was at the highest 18 days. During the exceptionally cold June in 1918 (see table p. 8) the period of incubation for a brood of eggs, laid on June 21st was 21 days. The longest liver of the four females died in the beginning of August 1918 after having produced five broods of eggs.

B. Summer-stock.

In order to investigate the growth and breeding conditions of *Gammarus locusta*, which have not wintered, I have taken some aquarium observations upon such individuals, partly collected from the free nature and partly hatched in the aquaria.

It would have been most natural to employ the manner of proceeding described above in experiment II, viz: the isolating of gammarids of the same stage in separate aquaria. These proceedings could, however, not be carried through, owing to the Station not commanding the number of aquaria necessary. I have therefore often been obliged to limit ny endeavours to making observations upon the growth and breeding conditions of the young in the same aquaria, where the adult gammarids were kept. The latter were very easy to distinguish from the young by their size, until the young grew to the same size as their parents. It was still more difficult when several successive broods of young appeared in the same aquarium, and in such cases it was not even possible to keep the different broods apart by a measurement of the stock. As, however, a continual supply of meat-

food was provided in the aquaria, it could be assumed that the earliest-born brood of gammarids must be sought among the largest, and the latest born among the smallest individuals of the stock of young in the aquarium; in the few cases where some of the gammarids could be distinguished from the others by certain peculiarities, this has always proved to hold good. Where the rate of mortality among the young had been exceptionally high, the results became too uncertain to be of any use, and for this reason only such aquarium observations are employed, in which the rate of mortality is either exceedingly low or at any rate so low that it has no influence upon the results obtained.

Experiment IV.

This aquarium experiment relates to the growth and the breeding conditions of a stock of young, hatched in aquarium during the month of May 1917; the young which were born in the month of May bred abouth the middle of August and in September of the same year; the males measured up to 17 mm in length, the females up to 15 mm. Upon the termination of the experiment on September 25th only one female was found breeding; at this time the males measured up to 20 mm and the females up to 17 mm. A comparison with the measurements of gammarids from the free nature (see table 1 and 2) shows that the gammarids from the aquarium have developed to a size quite unusual for the summer-stock, and that they have only commenced breeding, when of a length considerably above that at which gammarids breed in the free nature.

Experiment V.

This experiment comprises partly a stock of young hatched in aquarium between June 14th and 26th 1917, and partly a stock of 10 pairs of adult, mature gammarids of the summer-stock, which were placed in the same aquarium on June 28th of the same year. The experiment was concluded on September 22nd 1917.

It was proved that the young hatched in the aquarium became mature in the course of about 2 months after being hatched, 2 females having got their first brood of eggs in their incubatory pouches on August 11th; throughout the months of August and September copulating and breeding females were continually observed, but on September 22nd the breeding period was practically at an end. In common with experiment IV the young were, 2—3 months after being hatched, considerably larger than the average gammarid of the summer-stock from the free nature.

In reference to the 10 pairs of adult gammarids, the females were without eggs upon being placed in the aquarium, but each of them was in „riding-position“ with its mate, and it was observed that also gammarids of the summer-stock in aquaria breed several times during the summer, on an average twice a month; a period of 13 to 18 days passed between the first and the second oviposition,

9 to 14 days between the second and third, 15 days between the third and fourth and 20 days between the fourth and fifth oviposition. The longest living female had five broods of eggs between June 29th and September 1st.

Experiment VI.

A stock of young, hatched in aquarium by females of the wintered stock between June 1st and 6th 1917, commenced breeding hardly 2 months after being hatched, the females measuring then 16 to 17 mm. Throughout the months of August and September they were observed to be continually breeding, and the largest of the females had reached a length of 20 mm; but upon the conclusion of the experiment at the end of September of the same year the breeding period had practically ended.

This result corresponds thus exceedingly well with the results of experiments IV and V, and it was again proved here that the summer-stock in the aquaria quickly develops to a size considerably above that of the summer-stock in the free nature, at the same time of the year.

Experiment VII.

This experiment, which was the first I made with the *Gammarus locusta*, comprises about one hundred young hatched in an aquarium between April 16th and May 13th 1916 and thereupon isolated. The first breeding females of this stock were not observed before August 28th, 4 months having elapsed, and the breeding period lasted until the end of September 1916. Only 5 gammarids survived the winter, and on April 27th 1917 one of these had newly laid eggs in its incubatory pouch. As this gammarid without doubt had been breeding during the autumn, it appears that the summer-stock can breed as well during the autumn as in the early spring of the following year, a fact which is confirmed by experiments made later (experiment X). No further oviposition took place, and in the middle of June 1917 the whole stock had gradually died off after having lived one year in the aquarium.

Experiment VIII.

This experiment, which relates partly to young gammarids, hatched in aquaria between June 12th and 20th 1917, and partly to 11 adult pairs of gammarids of the summer-stock, placed in the aquarium on June 16th of the same year, showed firstly, that the young hatched in the aquarium matured in the course of about $1^1/_2$ month, when they had reached the same size as the adult gammarids; the first of their young appeared in the beginning of August. Secondly, the adult gammarids which were placed in the aquarium each obtained eggs twice a month on an average. The rate of mortality was high, there being on July only four females left; probably at least two of these have bred 5 times until the middle of August, but from this month, they cannot with any certainty be distinguished from

the growing young. The breeding activity decreased again during September; on October 2nd, upon the close of the experiment, only 2 of 49 females had eggs in their incubatory pouches.

Experiment IX.

In this aquarium experiment the development of a brood of young, born in the aquarium in June 1917, was studied. Though only two females became adults, they succeeded before October 9th 1917, when the aquarium was put away for the winter without daily control, in producing 6 and 7 broods of eggs respectively, though all these eggs did not result in viable young. However, the second brood of eggs was hatched into young, which reached maturity at the end of September and then produced a new generation of gammarids.

The development is evident in the accompanying scheme:

4 ♂ and 2 ♀, born abt. $^{15}/_{6}$ 1917

- Eggs 1st time abt. $^{20}/_{7}$. Of this brood, hatched $^{31}/_{7}$, only 1 ♂ became full-grown.
- Eggs 2nd time $^{1}/_{8}$. Of this brood hatched $^{11}/_{8}$-$^{13}/_{8}$, 1 ♂ and 3 ♀ became full-grown.
  - Eggs 1st time $^{10}/_{9}$. Young hatched $^{20}/_{9}$-$^{21}/_{9}$.
  - Eggs 2nd time $^{21}/_{9}$. Young hatched $^{2}/_{10}$.
- Eggs 3rd time $^{18}/_{8}$ and $^{19}/_{8}$. Of this brood no young resulted.
  - Eggs 3rd time $^{4}/_{10}$.
- Eggs 4th time $^{28}/_{8}$ and $^{30}/_{8}$. Of this brood young were hatched $^{10}/_{9}$-$^{11}/_{9}$.
- Eggs 5th time $^{11}/_{9}$. Of this brood young were hatched $^{21}/_{9}$-$^{22}/_{9}$.
- Eggs 6th time $^{24}/_{9}$ and $^{28}/_{9}$. Of this brood no young resulted.
- Eggs 7th time $^{4}/_{10}$. Of this brood no young resulted.

This aquarium experiment shows thus that it is possible, in the course of a good three months time, to produce 3 generations of *Gammarus locusta*. The first generation consisted of 4 males and 2 females born in the aquarium in the middle of June; both females commenced breeding about July 20th, and with a noteworthy regularity they got almost simultaneously new eggs on an average every 13th or 14th day in the succeeding months, until the one died on October 2nd of the same year after having had eggs 6 times; until October 9th the other female had produced 7 broods of young, but died some time between October 9th and November 19th same year, and no information was obtainable as to whether it hat carried eggs oftener. In accordance with the above the first generation was thus only a little more than a month in reaching maturity; the following generation was still quicker in growth, the first females which reached maturity having been born between August 11th and 13th and were observed carrying eggs the first time on September 10th—12th, i. e. just a month later. From their eggs the third generation was produced about September 21st, but it did not reach maturity before the winter, during which time no breeding took place; this generation did not become mature before April and May of the following year, and all the gammarids now continued to breed until they gradually died off, the last on August 5th 1918.

The size at which the gammarids born in the aquarium commenced breeding was much less than that stated in the previous aquarium experiments; with reference to the first generation the size was abt. 9—12 mm, with the second generation 7—11 mm, and these figures correspond entirely with the measurements of gammarids from the free nature.

Experiment X.

100 *Gammarus locusta*, comprising 50 males and 50 females with eggs or young in their incubatory pouches and caught among algæ in the Nyborg Fjord, were on June 28th 1917 placed in a glass bell, which was lowered beneath the surface of the water of Nyborg Fjord. The insignificant size ot the gammarids indicated that they all belonged to the summer-stock. The glass bell had 2 openings covered with canvas, the mesh of which allowed the newly hatched young — but not the adults — to leave the bell. On October 2nd 1917 the remaining gammarids were transferred from the bell to one of the usual glass aquaria, in which their further development was studied until the experiment was completed on September 20th 1918.

It was observed that the 100 adult gammarids of the summer-stock continued to breed from the time they were placed in the aquarium and till some time in October; from November till the beginning of February the breeding activity was inconsiderable, but from February it was again in full swing until all the gammarids gradually died off, the last male dying in the beginning of June and the last female in the beginning of July of the same year. The growth proceeded steadily the whole time, but was the least during the winter; the males grew the fastest, on an average abt. 14 mm in the course of hardly $8^1/_2$ months; during the same time the growth of the females averaged 7 mm. The rate of mortality was much higher among the males than among the females; upon the whole it was greatest in the months of July—September and somewhat lower during the winter. The young, which were hatched by the gammarids in the beginning of March, reached maturity in the course of about $2^1/_2$ months; they continued to breed during the whole summer until the beginning of September. The largest females were then 18 mm and the largest males 23 mm in length.

Experiment XI.

This experiment comprises 4 aquarium observations with several broods of young, which were born by 4 females of the winter-stock early in the year 1918 in cement- and glass-aquaria. In two of these aquaria the gammarids were fed with mussels, whereas no food was given in the two other aquaria but they contained living algæ, *Mytilus* and *Asterias rubens*, thus affording so far as possible conditions equal to those in the free nature.

The experiment was concluded on September 24th, 1918. With reference to the two aquaria in which no direct feeding was carried on, it was observed that upon the conclusion of the experiment only 13 males were left; in the other one

the young, which were born early in April, reached maturity already in the month of June of the same year. In one of the other two aquaria, in which a plentiful supply of minced mussel-flesh was provided, there were, however, only produced 2 females, and these did not reach maturity before August of the same year; in the other aquarium there certainly were a number of young, but none of these reached maturity before the winter. The growth, on the other hand, was greatest among the gammarids, which were fed.

The Results of the Aquarium Observations on *Gammarus locusta*.

From the aquarium observations mentioned above it is evident that *Gammarus locusta*, when kept in aquaria, usually breeds from the beginning of February till the beginning of October.

The gammarids which have wintered in the aquaria — the winter-stock — hatched in the beginning of March their first brood of young; after that they produced the one brood of young after the other, until they all gradually died off during the summer. In March—April each female had on an average only a single brood of young each month, but thereupon the period of incubation gradually decreased, and from June each female had about 2 broods of young every month. The longest living of the 60 wintered females, which were placed in an aquarium about the middle of April (Experiment II), died in the middle of August after having had 7 broods of young. Another adult female (Experiment I) got from April 30th 1917, when it was placed in the aquarium, and till September 15th of the same year, altogether 8 broods of eggs, the one brood following immediately upon the other.

The young hatched by the wintered gammarids in the beginning of March and which belong to the „summer-stock" matured in the course of $2^1/_2-3$ months, the females at a size of abt. 10—12 mm and the males at a size of abt. 12—14 mm (Experiment X). The later the young were born in the summer, the quicker they usually reached maturity; thus experiment VI shows that the young born in the first days of June reached maturity within two months, viz: on June 30th, and experiment V shows that the young born between June 14th and 26th also got eggs the first time within two months, viz: on August 11th; finally experiment IX shows that females born in the middle of June reached maturity about July 20th at a size of abt. 11 mm, and the young, born in the middle of August, matured exactly a month later at a size of 7—11 mm. The young born in September did not reach maturity before the winter, but all the gammarids born earlier continued to breed time after time until the termination of the breeding period. Like the females of the winter-stock, these smaller females of the summer-stock got on an average, reckoning from June, 2 broods of eggs every month, from the time they became mature and till October, when the breeding activity ended. Many of these gammarids, however, died before the winter; the remainder survived the

winter and in February commenced as „winter-stock" to breed again as described above.

A plentiful feeding with meat in the aquaria seems otherwise to cause a speedy growth of the gammarids at the expense of the development of the sexual organs. This is already suggested in the experiments IV, V, VII, and by the young mentioned in experiment X; to study this matter more closely experiment XI was arranged, and this proved that under otherwise like circumstances a number of gammarids, which were born early in the year by a wintered female in an aquarium, in which feeding was provided, either did not reach maturity in the course of the summer, or did not reach it before August; whereas gammarids in a corresponding aquarium in which no feeding was given, reached maturity in the first part of June, i. e. less than $2^1/_2$ months after being hatched.

Only a very few of the gammarids lived upward of one year in the aquaria; the most of them died within a much shorter time. As an example can be stated from experiment IX that a female born in the middle of June, died in the beginning of October of the same year after having had 6 broods of young; another female, born at the same time as the one just mentioned, died between October 9th and November 19th of the same year after having had at least 7 broods of young. Of 4 males which were likewise born in the middle of June, the two died already before the middle of August, and the other two lived until October 1st and 4th respectively; thus none of these gammarids survived the winter. One adult female lived in the aquarium from the end of April 1917 till March 9th the following year (experiment I). If this female really belonged to the winter-stock, which as stated earlier, its size was suggestive of, it would thus have been at least $1^1/_2$ year old, as in that case it must have been born at the latest in September 1916. As to the correctness of this assertion we have, however, no certainty; perhaps it has been hatched during the winter or very early in the year 1917 and has then grown unusually quick. The gammarids, which lived the longest in the aquaria, were a few hatched in the aquaria between April 16th and May 13th 1916 (experiment VII). The most of the hatched 100 gammarids died off during the summer; only about 10 individuals survived the winter, and the last gammarid died about the middle of June, which at the best gives an age of between $12^1/_2$ and $13^1/_2$ months.

The growth of *Gammarus locusta* in aquaria has already been partially treated in the above during the description of the separate aquarium observations. In fig. 3 the most important results are shown in the shape of curves, the recorded lengths and dates of the separate aquarium observations being marked off as ordinates and abscissæ respectively, and the points reached at being joined by straight lines.

Embody (9) as vell as Sexton and Matthews (22) have remarked that a higher temperature in the aquaria usually causes a decrease of time between the moultings of the amhipoas examined, and furthermore that this period was shorter with the young than with the adults. In conformity herewith the curves of fig. 3 show that the gammarids in the aquaria grow as well during summer as during winter, but that the growth progressed the quicker the warmer the season was. The young, which were hatched early in the spring and late in the autumn, were

more than 2 months in reaching a length of about 10 mm, whereas those, which were hatched during the warmest summertime, reached this size in less than a month. The growth was greatest with the quite young gammarids, and thereupon it gradually decreased; the males grew quicker than the females of the same brood.

The male which reached the greatest length in the aquaria measured 39 mm (experiment X); the largest female measured 24 mm in length (experiment II); I have never met with a female gammarid in the free nature that measured so much.

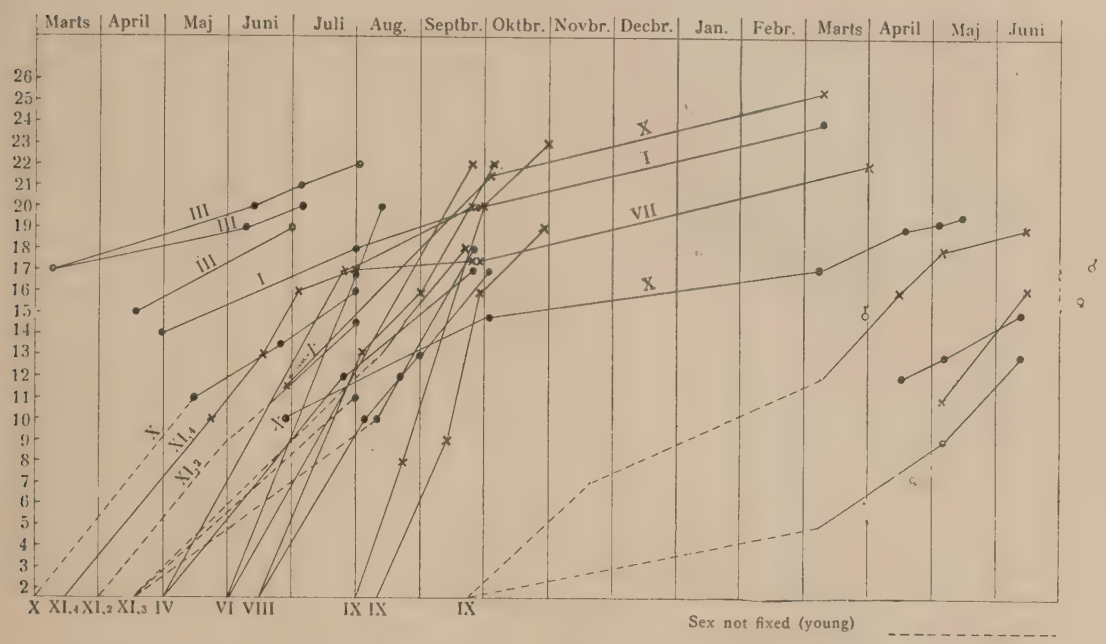


Fig. 3. The growth of *Gammarus locusta* in the aquaria.
Ordinates: Lengths in mm. Abscissæ: Dates.

Roman figures indicate number of the aquarium experiment. In experiments IV. VI, VII and VIII the curves represent the growth of the larger individuals of a stock. The other curves indicate, where nothing else is stated, the growth of the single individuals or the average growth of a stock.

Altogether the most of the aquarium observations show that many of the gammarids fed up in aquaria, quickly reached sizes that exceeded those, which the largest gammarids in the free nature ever reached at the same time of the year. Even if this certainly is mostly due to the strong meat-feeding in the aquaria, the fact that the animals in the aquaria are protected against attacks from other predatory animals, is undoubtedly of great consequence, as they thus get sufficient opportunity to devour all food they desire.

Notwithstanding the fact that the gammarids in the aquaria were protected against the attacks of predatory animals, the rate of mortality was very great, especially at certain times. Thus experiment II shows that among gammarids of the winter-stock (wintered gammarids) the rate of mortality, which was very low in the months of April—May (from April 17th till June 1st only 6,7 % of the females

died), increased greatly during the month of June (82% of 44 females); in July half of the remaining wintered females died off, and in August the rest. The rate of mortality among the summer-stock was, as experiment X shows, highest among the 100 gammarids during the three first months after being placed in the aquarium at the end of June, but it was exceedingly low during the whole of the winter. It is noteworthy that the rate of mortality was always highest amongst the males. The most critical time for the animals was the period about the moulting.

As to the causes of mortality it is stated in experiment II that a great number of deaths among the females fell on idividuals with unfertilized eggs. These unfertilized eggs were attacked by bacteria and infusories, and it is natural to suppose that these attacks of bacteria have spread to the animal itself and caused its death. As soon as a gammarid became weak it was assaulted by its comrades, and thus an attack of bacteria, which in itself might be of little consequence, could easily be the cause of death of the animal in question. The fact that during the winter, when the water of the aquaria was cold and no breeding activity took place amongst the gammarids, so few deaths occured, also supports the supposition of the bacteria or infusories forming a greater part of the cause of the high rate of mortality during the warmer seasons; on the other hand, however, it must be taken into consideration that while the wintered gammarids in the free nature all die before the end of July, several of the wintered gammarids in the aquaria continued to live till some time in the month of August. Furthermore several gammarids of the summer-stock, which were born in the aquaria, grew considerably older than, according to the measurement investigations, they would have done under normal conditions in the free nature (compare e. g. experiment X with calculations p. 38 of the lifetime of gammarid generations in the free nature).

The duration of the period of incubation proved to vary greatly in accordance with the temperature conditions of the aquaria. Experiments I, II, V and IX show that in the gammarids, which got eggs during the warm months of June and July 1917, distinct embryos were observed within the eggs in the course of 5—8 days after the eggs were laid; in the course of 9—12 days the young had broken their egg-shells and were swimming lively about in the incubatory pouch of their mother, and already in the course of another day the newly hatched young were about to leave this; the mother animals had usually empty incubatory pouches in the course of 11—15 days. On the other hand experiment III shows that the hatching of young in the cold months of March—April 1918 lasted about twice as long as in the warm season, there being hatched on April 8th young of eggs which were laid on March 20th 1918, and the incubatory pouch of the mother animal was not empty before April 14th, i. e. in the course of altogether 25 days. In the case of one gammarid, which got eggs on April 24th 1918, large embryos were observed within the eggs in the course of 21 days, and not before May 21st — i. e. after 27 days had elapsed — the mother animal's incubatory pouch was empty. In two other instances the period of incubation i. e. the time from the eggs were laid (April 19th and 29th respectively) and till the hatched young left their mother's incubatory pouch, was 21 days. While the month of June in 1917, as earlier stated, was a warm month, the month of June in 1918 was comparatively cold, there having been an exceptionally cold

time during the end of the month (see e. g. temperature for June 26th 1918 p. 8). The period of incubation proved to be twice as long in June 1918 as in June 1917, the most of the broods of eggs in June 1917 having been hatched in the course of 11—12 days, while in June 1918 the hatching of one brood of eggs, which was laid on June 12th, lasted no less than 21 days (experiment III).

In the aquaria the period of incubation lasted thus between 11 and 27 days, it being longer the lower the temperature was.

Moulting and mating usually ensued one or a few days after the last young had left the female's incubatory pouch; but several days previous hereto, at the time when its till carried eggs in its incubatory pouch, the female was usually seized by a male, which by means of the chelæ on its first gnathopods hooked itself firmly in the joint connections between the head and the first dorsal plate and between the 5th and 6th dorsal plates. In this „riding-position" (Della Valle (6) 1893, p. 279), as illustrated in fig. 4, it swam about for several days in the aquarium with the selected female, awaiting patiently the moment when the female should moult, after which the mating could take place. In conformity with the observations made by Sexton and Matthews on *Gammarus chevreuxi* (22, p. 550), a female, carrying newly laid eggs was never seized by a male, and should any male attempt to do so, the female would defend itself violently; but in the aquaria I have observed instances where females carrying eggs only five days old have been caught by a male, which was thus obliged to wait at least five days before mating could take place. When the gammarids moved about in the riding-position, the males always defended the females against attacks from the other gammarids, and when feeding took place they took care that the females dependant on them, smaller and weaker as they were, got their share of the food. The 2nd pair of the male's antennæ, which, in opposition to that of the female, is closely covered with long hairs, was always bent downwards, as shown in fig. 4, touching the female's antennæ while continually performing small quick movements. Upon taking a pair of gammarids in riding-position out of the aquarium, the male would, in its endeavours to get back to the water again, only in case of the greatest emergency let go its hold of the female even if the animals were subject to drying for a longer time. Usually it was not possible to part a male from a female withouth injuring the one or the other; I have even observed instances where not even death could part the male and female; thus the pair illustrated in fig. 4 is preserved in alcohol, which does not immediately act deleterious on the gammarids, and notwithstanding this the male has retained its firm hold on the female. Embody (9 p. 8) illustrates the male's chelæ in various positions during the riding-position amongst amphipods from North-America; with the *Gammarus locusta* the mentioned position seems always to be the same. Ussing (24) mentions the riding-position of the *Gam-*

Fig. 4. Gammarus locusta, ♂ and ♀ with eggs in its incubatory pouch, in „Riding-position". ♂ 18 mm, ♀ 11 mm. The Nyborg Fjord. Depth 3 feet, Zostera. May 15th, 1918.

marus locusta, but he states erroneously that Haempel was the first to substantiate that it is a mating-position. In reality the riding-position has nothing whatever to do with the mating position, which will be mentioned below; it must only be considered as a preparatory measure taken by the male to ensure its being present when the eggs are laid, in order that it may fertilize them.

With reference to the moulting of the gammarids it is a well known fact, which I have found to be confirmed through my aquarium observations, that the females moult immediately before laying a new brood of eggs i. e. during the warm summer time on an average twice a month, during February—May abt. once a month, and during the coldest winter-time with most probably still longer intervals. Regarding the moulting of the adult males, experiment IX gives the following information, which is not included in the report on this experiment: The largest males of the summer-stock moulted on August 16th, thereupon on August 28th, September 15th and September 26th of the same year, thus exactly as often as the females, viz. abt. twice a month. Regarding the male next in size the journal says that moulting took place on August 21st and again on September 22nd of the same year; the male third in size moulted on August 23rd and on September 21st of the same year. In these cases there is a period of one month between each moulting, which is in conformity with Sexton and Matthews (22 p. 551). The moultings took place in a corresponding manner to that described by Embody (9 p. 21) in reference to fresh-wather gammarids. As soon as a gammarid had moulted, is was easily distinguishable by its dull and opaque appearance. Immediately after the moulting had taken place the gammarids were usually very quiet, and prefered to hide under some object or other; but in the course of at the most 2 days the chitin plates had again their normal firm and shiny appearance and the animal could now move freely about; the adult males, which never during or immediately after a moulting endeavoured to associate with the females, could now again seize a female and move about with it in riding-position, waiting for days that the female should moult, whereby it would be able to fertilize the eggs.

The mating proceeds in a similar manner as with the closely related forms: *Gammarus pulex* and *Gammarus pungens*, which are described by Della Valle (6, 1887—89, and 1893 p. 278—79) and *Gammarus chevreuxi*, described by Sexton and Matthews (22 p. 550—51). The reason why the female must moult before the mating and oviposition can take place is that the oviducts, as is the case with *Gammarus pulex*, described by Della Valle (6, 1887—89), lack outer openings in the firm chitin plates*). The moment the female commences to moult the riding

*) Only Haempel (11) is of the opinion that the moulting of the *Gummarus pulex* and *Gammarus fluviatilis* does not take place before the mating is over; he believes he has observed that the female, immediately after the male has disposed its sperm upon the female's ventral side, secretes a fluid that opens apertures in the chitin plate, through which the spermatozoa, being released by means of the same fluid of the tough mass surrounding them, penetrate and fertilize the eggs, these having in the meantime entered the oviduct. The moulting should now take place after this. This observation is, however, in strong opposition to the results of all other observations as well in reference to *Gammarus pulex* as to other closely related forms. Haempel observed furthermore, and this too is in direct opposition to what took place with *Gammarus locusta* inve-

male's antennæ move faster and faster, and without releasing its hold on the female for one moment, it seeks to a lonely and safe corner of the aquarium for the mating. At times it helps its mate to cast the old skin by pulling at both ends of it with chelæ and legs. Soon after the female has completed the removal of its skin, this usually only lasting a few minutes, the male, which has not for a moment released its hold, turns round to a position across the body of the female at the same time bending its front and hind parts in beneath the ventral side of the female (fig. 5). The male's atennæ are continually moving, examining the parts around the incubatory lamellæ; in this „mating-position" the mating takes place in the course of about an hour, the male pressing several times with sudden jerks the ventral side of the part about 7th joint in beneath the ventral side of the female, where the sperm is disposed. Della Valle (6, 1893, plate 50, fig. 1) has illustrated and described a somewhat deviating mating position in reference to *Gammarus pungens*. After the mating the male immediately releases its hold on the female, and though I have not been able to observe it directly, the laying of the eggs in the incubatory pouch of the *Gammarus locusta* takes place most certainly immediately after the mating, in the same manner as observed by Della Valle (6, 1893) and Sexton & Matthews (22) with *Gammarus pungens* and *Gammarus chevreuxi* respectively. Directly after the mating both male and female are very exhausted and usually hide themselves. As a result of the moulting the female has a remarkable opaque, greyish appearance,* because the new cuticle has not yet obtained its normal firmness and lustre, and during this period the animal is evidently very sensitive, which the many deaths amongst the females in the aquaria prove.

Fig. 5. Gammarus locusta. ♂ and ♀ in mating-position. ♀ has just cast the old skin. Drawn from living subjects in aquarium. June 1917.

The Results of Measurement Investigations compared with the Results of Aquarium Observations.

Measurements of *Gammarus locusta* from the Nyborg Fjord have proved that this species is annual, as the whole wintered stock dies off every summer during the months of June and July. This agrees very well with the fact that the longest life-time of *Gammarus locusta* in the aquaria was about one year (see p. 28); the most of the gammarids died, however, before they reached so high an age. A few single individuals of the wintered females seem enabled to live

* stigated by me, that after mating the male very seldom released its hold on the female, but remained in riding-position; however, a male seldom mated a second time with the same female, but sought another.

somewhat longer in the aquaria than in the free nature. Thus experiment II shows that though the most of the wintered stock of 60 individuals died during the months of June and July, a single individual lived until the middle of August.

The measurement investigations show furthermore that some of the wintered gammarid females commenced to get eggs in their incubatory pouches at about the end of January. Gradually more and more became mature, and in April all the females of the wintered stock had reached maturity. Though a few young are hatched already in the month of March, a numerous stock of newly hatched young is not observed in the free nature before April. Corresponding to this the aquarium observations showed that the duration of the period of incubation was dependent of the water's temperature, according to which the hatching of eggs, wich were laid in March, lasted about a month, which is twice as long as is demanded in the warmest summer time (June—August); it is therefore reasonable that the hatching of eggs laid as early as January lasts a somewhat longer time, the temperature of the water being lower in January than in March (see table of temperature p. 8).

In conformity with the aquarium observations, which showed that females of the winter-stock got the one brood of young after the other, from the time they commenced breeding early in the year and until they died, the tables of measurements from April till July show continually a large group of newly hatched young, while the females of the winter-stock still carry eggs or young in their incubatory pouches, until in the course of July they disappear entirely from the tables. The very few females, which during the summer months were found without eggs or young in their incubatory pouches, and which never the less by their considerable size proved to belong to the winter-stock, were, as mentioned earlier, spent individuals having empty ovaries and being on the verge of death, exhausted by the repeated egg-layings. The fact that the same female can breed several times, is distinctly evident by the ovaries of the egg-bearing females being the more developed, the further the hatching of the eggs in the incubatory pouch has progressed. In females carrying eggs containing embryo with pigmental eyes, large well-developed eggs could easily be distingished in the ovaries. A female with such developed ovaries was nearly always accompanied by a male, which held it in riding-position ready to fertilize the new brood of eggs, as soon as the young of the preceding brood had left the mother's incubatory pouch. In a female measuring 20 mm and having 70 young in its incubatory pouch, the ovaries proved to contain abt. 70 nearly fully developed eggs with large light germinal vesicles. In a female measuring 13 mm with 60 young in its incubatory pouch, the ovaries contained at least 40 eggs measuring abt. $0{,}_5 \times 0{,}_3$ mm; as newly laid eggs from the incubatory pouches of gammarids of a like size measure about $0{,}_5 \times 0{,}_4$ mm, it will be seen that the mentioned ovary eggs were fully developed and ready for fertilization. In the aquaria there have been observed instances, where a single female got 8 broods of eggs in succession, but this individual continued breeding until some time in September, at which time the whole of the winter-stock in the free nature had died off. In accordance with the above it must be assumed that the longest living of the wintered females at the highest can get 7 broods of young in one breeding period, viz. the 1st brood in the

middle of March, the 2nd in the middle of April, the 3rd in the middle of May, the 4th and 5th in June and the 6th and 7th in July.

According to the measurement investigations the earliest born of the young from the winter-stock matured in May, and this conforms very well with the aquarium observations, according to which the young born in the beginning of March got eggs in the middle of May and thereupon continued to breed throughout the whole summer, if they did not die before; as the water became warmer the latest born young matured quicker; if they were born in June, maturity was reached in the course of $1^1/_2-2$ months; were they born in August it lasted only a month. In the tables of measurements we find in conformity herewith, throughout the whole summer but mostly in September, a stock of small breeding females; in October, however, the breeding activity ceases, as well in the free nature as in the aquaria, and the females born in aquarium in September do not reach maturity before the winter, but are obliged to wait till the next year to breed. During the whole winter, however, a few breeding females may be found in the free nature, but they form only a very small percentage of the entire stock, and in the aquaria such females never produced viable young.

While it could often happen in the aquaria that a few days passed before a female, after having hatched a brood of young, again got eggs in its incubatory pouch, the lack in the table of measurements of large spent females with empty incubatory pouches show that in the free nature the hatching of young is followed immediately by a new laying of eggs.*) It must therefore be taken into consideration, when in the following only two egg-layings a month are reckoned with, that this figure is very low. Owing to the fact that the period of incubation during the warm summer-time only lasts 11—12 days, it would be better to reckon that in the free nature each adult female hatches, from the beginning of June, 5 broods of eggs in the course of 2 months. In experiment IX there were 13 to 14 days between each laying of eggs, and one female of the summer-stock got eggs 7 times in succession, first time about July 20th and last time on October 4th. As such a female, according to what has been learned from experiment X, very well can survive the winter and breed again the next year from February till some time in the month of July, and in this time produce another 7 broods of eggs, the result would be that a single female at the best could produce altogether 14 broods of young.

With reference to the growth of gammarids the tables of measurements do not supply much information, as throughout the whole summer new young are continually being produced and the various generations cannot be kept apart. It must, however, be noted that according to the measurements, it is evident that the gammarids grow slower during the months of October—February than during the months of March—April. Fig. 1 shows that on September 28th 1916 the average length of the entire stock of measured gammarids was 8,77 mm; on

*) Haempel (11) states that after hatching of the eggs the *Gammarus pulex* in his aquaria went for 8 days in „copulation position", with which shall be understood riding-position, but this is most certainly a situation brought about by the somewhat unnormal conditions of the aquaria. It is regretable that he has not investigated samples from the free nature.

February 15th 1917 it was 12,38 mm; during the intervening $4^1/_2$ months the stock, which meanwhile had not received any notable increase in the number of young, had increased in length on an average with 3,61 mm; but during the two months from February 15th till April 14th 1917 the increasement in length averaged no less than 3,18 mm. Corresponding hereto the curves of growth referring to aquarium experiments IX and X (fig. 3) from the month of March show a considerable rise after the comparatively slower growth during the winter. The measurements furthermore show that males grow faster than females; as will be noted, the males included in the tables of measurements are always larger than the females; the measurements from February 15th 1917 and April 14th 1917, both of which refer to the winter-stock only, show that in the course of the intervening 2 months the average length of the males has increased with 3,61 mm viz. from 14,14 mm to 17,75 mm, whereas the corresponding average growth of the females amounts to 3,01 mm, viz. from 11,01 to 14,02 mm (the last two measurements referring as well to females with eggs as to females without eggs). Upon comparing these figures with those relating to the growth of gammarids, which have wintered in the aquaria, as mentioned in experiments IX and X, of which experiment X comprises a stock of gammarids born early in the year (in March or April) and experiment IX a stock born late in the year (in September, see fig. 3). it will be observed that the curve of growth for gammarids from the free nature, if inserted in fig. 3, would lie between or about parallel with the curve of growth for gammarids from experiments IX and X. As the winter-stock from the free nature comprises all the gammarids born between March and October, there is here a good conformity between the aquarium observations and the measurement investigations. The same refers to the size at which the gammarids of the summer-stock matured. The tables of measurements (table 1 and 2) show that the smallest egg-bearing females in May measured 9 mm, in June 8 mm, in July 7 mm and in August only 6 mm. Corresponding hereto the first-born gammarids of the summer-stock in the aquaria matured in May at a size of 10 to 12 mm (experiment X), in June at a size of less than 9 mm (experiment XI); in the month of July 2 gammarids of the summer-stock commenced breeding at a length of about 7 mm (experiment IX). In many other cases the gammarids in aquaria, as mentioned earlier, grew to a size, which at the time of year in question was unknown in the free nature (see e. g. experiments IV, V, VI, IX and XI); the cause of this is either due to the strong feeding with meat in the respective aquaria, or it can be accounted for by the fact that the gammarids, as they grow up in the free nature, either die a natural death or are devoured by fish or other animals. The first of the reasons mentioned is not in itself sufficient, as e. g. experiment XI shows that though the gammarids in aquaria without artificial feeding with meat did not grow so quickly as the gammarids in the other aquaria, they grew to a much larger size than the gammarids in the free nature at the corresponding time of the year. Thus e. g. the males reached an average size of 17,5 mm in September, in which month the tables of measurements show that only 3 gammarids of 6652 individuals measured were above 16 mm in length. It is most improbable that fish or other animals should preferably devour the larger individuals, as the small gammarids are just as desirable as the adults, and besides do not hide as these amongst

stones, mussels and the like; furthermore the wintered gammarids reach in the months April—June a considerable size. It will be noted from the measurements that the largest male was 33 mm in lenght and the largest female 23 mm; I have never been able to produce males of this size in the aquaria, and only a single female reached a size of 24 mm; none of the other females ever reached a length exceeding 22 mm.

It has already been stated that the wintered adult gammarids grew more than 3 mm in the course of 2 months, from February 15th till April 14th; the aquarium observations proved too that the growth of the gammarids was largest during the warm summer months, and that the young grew quicker than the old. In accordance herewith the young gammarids, which were born early in the year and which reached maturity in the middle of May at a size of at least 10 mm (see p. 36), should already in September be a least 16 mm in length. Such large females have never been found in the month of September, and even if the fish should have devoured some of them, there would surely have been a few single individuals left. One is therefore entitled to surmise that the gammarids born early in the year do not normally survive the summer. To be sure they can do so in the aquaria, though the most of them die beforehand, but that is no proof of the same thing taking place in the free nature; many of the wintered gammarids lived thus in the aquaria a long time after the last wintered gammarids in the free nature had died off.

With the exception of the few discrepansies stated here, it appears from the foregoing that the results of the aquaria observations conform in all essentials very well with the results gained through the studying of the gammarids in the free nature; it stands therefore to reason than one is entitled to assume that the other results obtained through the aquarium observations, and which cannot be directly controlled, may also conform with the actual conditions of the free nature. This refers especially to the questions as to how many generations of *Gammarus locusta* may be produced in the course of the year, and as to when maturity sets in and the duration of the period of incubation.

It will be remembered that the young, born in the beginning of the year, appeared in the month of March; in this respect the aquarium observations and the measurement investigations conform to each other. In calling a brood of young born in the beginnig of March for Generation I, the aquarium observations as well as the measurement investigations show that this generation matures in May; according to the aquarium observations experiment III the period of incubation during this month lasts 20 days, and the first gammarids of Generation II may thus be assumed to appear about the end of May. These gammarids must according to the aquarium observations (see especially experiments VI and IX) be assumed to mature about the middle of July, in which month the period of incubation in the aquarium lasts about 11 days. The first born gammarids of Generation III appear thus about the end of July, and as the gammarids born in this month, according to the aquarium observations, are a little more than a month in maturing and the period of incubation lasts about 10 to 15 days, a Generation IV appears in September, but this generation does not attain maturity before the winter arrives.

In the course of the summer no less than 4 generations are thus produced;

as furthermore the first three of these may be assumed to continue breeding as long as the breeding period lasts, each adult female producing 2 broods of young every month (if they do not die beforehand) and as the females of the winter-stock too, from March till some time in June produce the one brood after the other, it will easily be understood that the tables of measurements throughout the summer show an immense group of newly hatched young, and that the number of breeding females culminates in the month of September (see fig. 2). However, in accordance with the statements set forth above (p. 37), all the gammarids of these four generations cannot normally be assumed to live throughout the summer. In order to obtain some idea as to how long each of them can be supposed to live, I have made the following contemplation. The first born gammarids of Generation I, as will be remembered, are to be found amongst the smallest breeding gammarids, and it will be noted from the measurement tables that in the month of May the smallest female with eggs measured 9 mm. It is stated earlier that the large females of the winter-stock increased 3 mm in length from February till April of the same year. The small females just mentioned must certainly grow just as quickly, and probably even quicker. If, however, the growth is put at $1^1/_2$ mm per month during the summer-months, they will have reached by August a length of at least 13,5 mm; but the tables of measurements show, that the largest female found in this month measured 13 mm, and accordingly the first born females of Generation I must have died off before the month of August of the same year. This referred to the gammarids of Generation I born in March; it must be assumed that these have averaged only 5 broods altogether, viz: the first in May, the next two in June and the last two in July. The gammarid females born in April and which according to the foregoing mature in the following June (see e. g. experiment XI) must be sought among the smallest females with eggs in the tables of measurements for June, which show that they measure 8 mm. Calculating in the same manner as described above, it will be found that these gammarids should reach a length of $12^1/_2$ mm in September; but the measurements for this month do not include breeding females of such a length. They must therefore either have ceased breeding, which is very improbable, as the breeding period is not yet at an end, or they must have died beforehand; from the end of June till the beginning of the following August they may have produced 5 broods of young, viz. one brood in June, 2 in July and 2 in August. The gammarids of Generations I and II, which are born in May reach maturity in July of the same year, and in this month the smallest breeding females measure 7 mm; in September they are then at least 10 mm in length, and may therefore be found amongst the largest breeding females of the measurement tables for this month, there being 79 individuals measuring 10 mm or more among the females with eggs measured in September, of which there are altogether 568 individuals (see tables 1 and 2); before the end of September they may have been able to produce 6 broods of young, viz.: 2 in July, 2 in August and 2 in September. The gammarids born in late June, July and August, which belong partly to Generation III and partly to earlier generations and which reach maturity in August and September of the same year at a minimum length of 6 mm, must be assumed to form the greater part of September's large group of breeding females,

the average length of which is abt. 8 mm. (see fig. 2); during this time the earliest born may on an average have had about 4 broods of young, viz. 2 broods in August and 2 in September. Judging from the aquarium observations (see e. g. experiments IX and X) a great number of these gammarids, having been breeding in the autumn, continue without doubt to live the whole winter, to commence breeding again in the following spring. The same must refer to the gammarids of all 3 Generations born as late as August and which only breed a couple of times during September and then live throughout the winter.

It will be understood that with the experiences gained through the foregoing, exhaustive information regarding the biology of these animals is only obtainable through a combination af aquarium observations and investigations of the stock in the free nature. Most probably this may also refer to many related crustaceans; Ekman's results (8), which are based exclusively upon observations from the free nature, and these forming moreover a much too small material, are therefore for a greater part of most doubtful value. In particular I am of the impression that the author often confounds the young of the year with animals more than one year old (see e. g. p. 552 and 555), whereby he reckons the animals to be a year older than they really are. It is, however, impossible to judge this before a closer examination has been made, and the material in the paper is most valuable as a foundation for such. Dahl's investigations of *Gammarus pulex* (5) are founded upon exceedingly good observations from the free nature; but in going over his tables of measurements, they cannot be said to exclude the possibility that the same individual may get several broods of eggs in the course of a breeding period, as the case is in Denmark (see p. 55). The tables of measurements do not show any dying off of all the spent adult gammarids during the summer, and it is therefore probably quite correct that the species is biennial or may live several years; on the other hand it appears to me as most improbable that two years should elapse before the young reach maturity, the spring samples clearly showing that by far the greatest number of the whole stock of females at this time of the year have either visible ovaries or eggs (or young) in their incubatory pouches; they are thus mature and the remainder are perhaps spent individuals.

In order to give some idea as to the average number of young every gammarid female hatches in each brood, I have stated below the results obtained from a number of countings of eggs in the incubatory pouches of eggbearing females included in the tables of measurements. The eggs are carefully picked out of the incubatory pouch by means of a needle and tweezers beneath a binocular microscope and thereupon counted. It would have been still better if it were possible that the number of young hatched was determined by counting them before they had left the incubatory pouch of the mother animal, because it happens that some of the eggs do not develop into young; I have at times found dead eggs in the incubatory pouch simultaneously with fully developed young. Among the breeding females there are, however, only a few individuals with newly hatched young in their incubatoring pouch, as according to the aquarium observations, only a very short time seems to elapse from the moment the young leave the eggs till they begin to swarm out of the mothers incubatory pouch, and furthermore the young easily fall, before and during the preserving, out of the

The mother animal's length in mm.	21. January 1918. From Mytilus.	15.–16. February 1917. From Mytilus and algæ.	7.–12. March 1918. From Mytilus and algæ.	14. April 1917. From Mytilus.	18. May 1918. From Mytilus.	24. May 1916. From Mytilus and algæ.	7. June 1917. From Mytilus.	23. June 1916. From algæ.	4. July 1917. From Mytilus and algæ.	2. August 1917. From Mytilus.	4. og 5. August 1916. From Mytilus and algæ.	6. Septbr. 1916. From algæ.
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$8_{,5}$ (4)	$8_{,6}$ (5)
7	.....	.....	.....	.....	.....	.....	.....	.....	11 (2)	.....	$11_{,3}$ (6)	$12_{,6}$ (12)
8	.....	.....	10 (5)	.....	....	.....	.....	12 (4)	$13_{,1}$ (6)	$7_{,9}$ (7)	$17_{,1}$ (15)	$20_{,1}$ (12)
9	.....	12 (2)	$11_{,3}$ (7)	.....	20 (1)	.....	$25_{,5}$ (2)	$21_{,4}$ (5)	$17_{,7}$ (11)	$12_{,1}$ (12)	$22_{,9}$ (11)	$29_{,4}$ (11)
10	11 (2)	$15_{,1}$ (7)	$15_{,1}$ (10)	21 (1)	33 (3)	23 (3)	27 (4)	28 (2)	$27_{,4}$ (7)	$15_{,6}$ (7)	$34_{,7}$ (8)	$37_{,7}$ (9)
11	15 (2)	19 (9)	$18_{,9}$ (9)	28 (4)	$41_{,4}$ (5)	$49_{,3}$ (6)	43 (5)	35 (3)	33 (3)	$19_{,5}$ (4)	$48_{,3}$ (6)	$35_{,4}$ (7)
12	$19_{,8}$ (5)	$23_{,5}$ (10)	22 (14)	36 (5)	45 (7)	67 (6)	$45_{,5}$ (8)	$50_{,3}$ (3)	40 (2)	26 (2)	60 (1)	41 (1)
13	25 (3)	30 (7)	28 (13)	41 (6)	$50_{,7}$ (4)	76 (6)	$59_{,3}$ (9)	84 (2)	61 (1)			
14	$27_{,5}$ (4)	$35_{,1}$ (7)	30 (4)	$57_{,8}$ (6)	$55_{,2}$ (4)	99 (7)	$65_{,8}$ (5)	$91_{,8}$ (4)				
15	30 (1)	52 (1)	51 (2)	75 (7)	$76_{,5}$ (2)	110 (6)	.....	$123_{,5}$ (2)				
16	.....	.....	64 (1)	$54_{,5}$ (2)	.....	136 (5)						
17	.....	.....	64 (4)	71 (2)	.....	.....						
18	.....	.....	73 (2)	142 (1)	97 (1)	112 (1)						
19	.....	.....	.....	102 (2)	.....	.....						
20	.....	.....	.....	130 (1)	100 (1)	.....						
21	.....	.....	.....	.....	.....	152 (1)						
22	.....	.....	.....	127 (1)								
Number of individuals examined	17	43	71	38	28	41	33	25	32	32	51	57

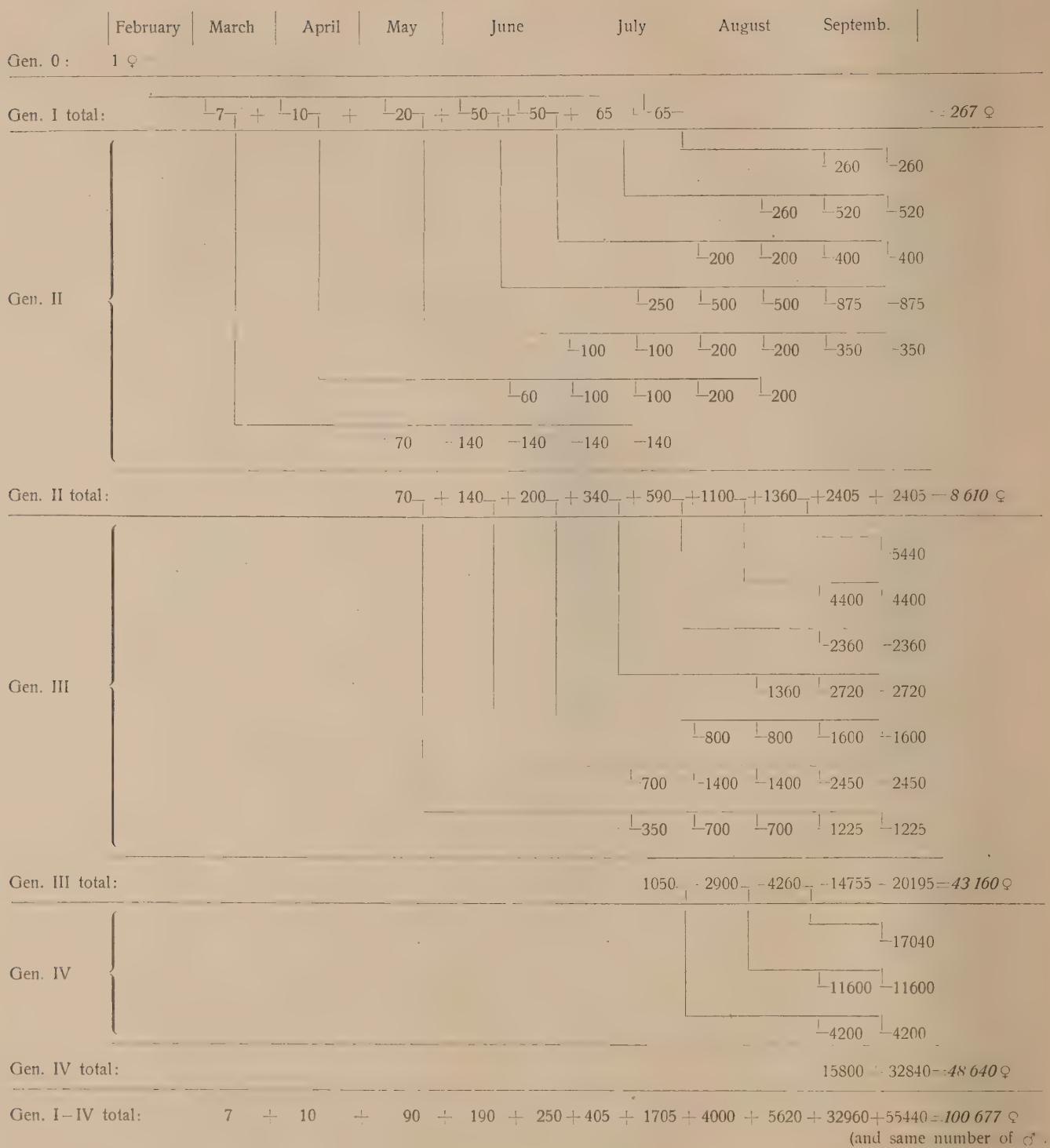
The average number of eggs in the incubatory pouch of *Gammarus locusta* from the Nyborg Fjord. The figures in brackets indicate number of individuals examined.

incubatory pouch; this manner of proceeding had therefore to be abandoned. It will be remarked that the number of eggs, in conformity with the investigations made by Embody (9, p. 12), Samter and Weltner (21, p. 691) and Sexton and Matthews (22, p. 552) increases with the size of the gammarids; this again means that the older the gammarids become, the greater number of eggs — or young — they get in each brood. But the scheme shows furthermore that within the same group of size the number of eggs increases considerably from the beginning of the breeding-period till later on in the summer, when the winter-stock gradually dies off. The existence of a similar increase cannot with any certainty be proved in the case of the summer-stock, but the figures tend to show that the number of eggs obtained by gammarids of the same length were on an average larger in 1916 than in 1917. Especially August 2nd 1917 shows a surprisingly low number of eggs; this is apparently no accidental circumstance, as the separate figures lie close to each other and afford a steady increase according to the size of the gammarids; it must be due to some certain reason e. g. a suddenly occuring cold period during the development of the eggs.

Embody's calculation of the number of descendants of fresh-water gammarids (9, p. 25—29) is partly based upon the counting of eggs; the average number of eggs of the 4 species amounted to 18 (the smallest species), 45, 22 and 75 (the largest species) respectively. Furthermore the growth of the young in aquaria was investigated, and by means of the curve of growth the age of the smallest breeding females found in the free nature was determined; through this most remarkable results were obtained, such as the young of *Gammarus fasciatus* should be able to reach maturity in the course of 39 days, though in Embody's experiments young of this species were kept in the aquaria for 180 days without any of them becoming mature. Neither has any consideration been taken to the fact that the growth of amphipods in aquaria cannot thus offhand be set as equal to the growth in the free nature, and in the case of one species, *Eucrangonyx gracilis*, the curve of growth, which only shows the growth in the aquarium during 180 days, is continued in a straight line for a distance which is twice as long as the remainder, and from which the author infers that this species does not become mature before it has reached an age of 497 days! It is obvious that an approximately correct result cannot be based upon such unreliable foundation.

In order to render plain the immense fecundity of these animals I have, by means of the figures given here and in the foregoing, prepared the bystandig hypothetical scale of the descendants of one pair of wintered *Gammarus locusta* in the course of a breeding period; it is assumed that the female in February had eggs first time at a total length of 10 mm. To render the scale more plain I have only stated the number of females. In order not to reckon too high I have calculated that during the months of February—May each female had only one brood of young each month, and in June—September 2 broods each month. Likewise I have set the increase of growth of the mature gammarid females at 1,5 mm per month.

According to the table p. 40 the average number of eggs in a ♀ measuring 10 mm in length in the month of February amounts to about 15. Assuming in the following that all the eggs are hatched to viable young and that equal numbers of ♀ and ♂ are hatched in each brood


February
March
April
May
June
July
August
Septemb.
Gen. 0 : 1 ♀
Gen. I total: 7 + 10 + 20 + 50 + 50 + 65 + 65 = 267 ♀
Gen. II
260 260
260 520 520
200 200 400 400
250 500 500 875 875
100 100 200 200 350 350
60 100 100 200 200
70 140 140 140 140
Gen. II total: 70 + 140 + 200 + 340 + 590 + 1100 + 1360 + 2405 + 2405 = 8 610 ♀
Gen. III
5440
4400 4400
2360 2360
1360 2720 2720
800 800 1600 1600
700 1400 1400 2450 2450
350 700 700 1225 1225
Gen. III total: 1050 + 2900 + 4260 + 14755 + 20195 = 43 160 ♀
Gen. IV
17040
11600 11600
4200 4200
Gen. IV total: 15800 + 32840 = 48 640 ♀
Gen. I – IV total: 7 + 10 + 90 + 190 + 250 + 405 + 1705 + 4000 + 5620 + 32960 + 55440 = 100 677 ♀
(and same number of ♂ .

(the aquarium observations showed that this usually was the case), I have calculated that the 1st brood of Generation I, which was hatched in March, comprised 7 ♂ and 7 ♀. In March the mother animal, in the table called Generation 0, has in the meantime reached a size of $11_{,5}$ mm, and in accordance with the table page 40 has about 20 eggs in its incubatory pouch. These eggs, the 2nd brood of Generation I, are hatched in April and result in 10 ♂ and 10 ♀. In April the ♀ of Generation 0 has grown to 13 mm and gets now about 40 eggs, which in May result in 20 ♂ and 20 ♀, the 3rd brood of Generation I. In May the mother has reached a size of $14_{,5}$ mm and gets therefore, according to the table for May 24th 1916, wich relates to the greatest number of examined individuals, at least 100 eggs in its incubatory pouch, but as it hatches two broods of young in the months of June and July, the table page 40 gives an offspring of twice 50 pairs of gammarids for June, the 4th and 5th broods of Generation I. During the same month the ♀ of Generation 0 has increased to a size of 16 mm; as no counting of eggs has been made on ♀♀ of this size in the month of Jnne, the figure of the table page 40 for May 24th viz: an average of 136 eggs in 5 individuals, has been taken, being reduced to 130 as a more convenient figure. In July there are thus 2 broods of young each containing 65 ♂ and 65 ♀; but after having in this manner produced no less than 7 broods of young the Generation 0 dies off.

The 7 ♀ born in March, the 1st brood of Generation I, reach maturity in the course of May at a minimum size of 9 mm (see page 36). One ♀ of this length carries, according to table page 40, 20 eggs in its incubatory pouch; at the end of the month there is therefore hatched $7 \times 20 = 140$ young, of which the half are ♂, and the other half ♀; this is the first brood of Generation II; in June the 7 ♀ of Generation I have grown to a size of at least $10_{,5}$ mm, and according to the table stating the number off eggs in gammarids from June 7th 1917 (I have chosen this because it contains the greatest number of examined individuals), they get between 27 and 43 eggs in their incubatory pouches. As, however, the most of the gammarids must be assumed to be at the least 11 mm in length, the number of young hatched in June can safely be estimated at an average of 40 in each of the 2 broods, especially as the mother grows a little during the moulting between the two laying of eggs. This gives therefore 2 broods of young each comprising 140 ♂ and 140 ♀. In July the 7 ♀ of Generation I are at the least 12 mm in length; according to the table p. 40 the number of eggs in each ♀ of this length in July is still 40, so that in this month another 2 broods of young are born, each comprising 140 ♂ and 140 ♀. As was seen in the foregoing, the ♀♀ of the 1st brood of Generation I have by this time ceased breeding, as they must be supposed to die off during August. The 10 ♀ of Generation I, 2nd brood, reach maturity in June at a minimum size of 8 mm. Their 1st brood of young is born at the end of this month. According to the table p. 40 it must be assumed that each ♀ produces 12 young, i. e. altogether 120 young, 60 ♂ and 60 ♀. In July the mother animal has reached a length of at least $9_{,5}$ mm, and accordingly the number of eggs is at the least 20, which totals 100 ♂ and 100 ♀ in each of the 2 broods. In August the 10 ♀ of Generation I measured at least 11 mm; the number of eggs of each ♀ in this month is set at 40, because, in the table p. 40 as mentioned above, the number of eggs for August 2nd 1917 cannot be taken into consideration, exceptional conditions having been prevailing, but only the figures from August 4th and 5th 1916; 2 broods of young, each comprising 200 ♂ and 200 ♀, is the result of the breeding activity during August, but thereupon the ♀♀ of Generation I born in April must be assumed to die or at any rate to cease breeding (see page 38). On the other hand the longest living of the 3rd brood of Generation I, which are born in May, begin breeding from the beginning of July until the end of September. Assuming that all the 20 ♀ in the table live and breed so long, they get in July, when their average size is 7 mm, 2 broods each of abt. 10 young, which gives a result of 100 ♂ and 100 ♀ in each brood. In using the same proceedings as in the above, it will be seen that each of the 20 ♀ of 3rd brood, Generation I, which in August measure at least $8_{,5}$ mm in length and in September at least 10 mm, get in August 2 broods of young each comprising 20 gammarids and in September again 2 broods of about 35 gammarids each. The ♀♀ of the 4th brood of Generation I, born in the first part of June, reach maturity by the end of July at a minimum size of 7 mm; in this month they get only 1 brood of young, comprising about 10 individuals, which for 50 ♀ amounts to 250 ♂ and 250 ♀. In accordance with the method of calculation stated in the foregoing, they get 2 broods of young in August, each brood comprising 500 ♂ and 500 ♀, and in September another 2 broods each comprising 875 ♂ and 875 ♀. The 5th brood of Generation I, born during the latter half of June, does not reach

maturity until August at a minimum length of only 6 mm, for which reason each of the 50 ♀ only gets 8 young (see table p. 40), which altogether amounts to 200 ♂ and 200 ♀ in each of the broods born in August. In September the mother animals are $7_{,5}$ mm in length and accordingly get 16 eggs (the mean of 12 and 20, which according to the table p. 40 are the numbers of eggs for ♀♀ of 7 and 8 mm length respectively), which amounts to 400 ♂ and 400 ♀ in each of the 2 September broods. The 65 ♀ of the 6th brood of Generation I each get 8 young during August at a size of 6 mm; in September, when of a size of $7_{,5}$ mm, they again get 2 broods each comprising 16 young. The last born brood of Generation I gets only 2 broods of young, namely in September; as the minimum size of eggbearing ♀♀ in September is 6 mm (see table 1 and 2) each ♀ gets only 8 young. The 65 ♀ get thus in each brood altogether 520 young, of which the 260 are ♂ and the 260 ♀.

While Generation I only comprises 267 ♀ in all, Generation II has reached a total of 8610 ♀, of which those born before September can be assumed to breed as follows: the 1st brood which is born about the end of May does not get young before the last part of July; their size is therefore set at 7 mm, and the number of eggs at 10; in August they get two broods each of 20 eggs, in September 2 broods each of 35 eggs, continually in accordance with the manner of calculating mentioned above. The 140 ♀ of the 2nd brood of Generation II, which are born during the first days of June, may be assumed to breed simultaneously at the same size and accordingly with the same number of eggs. The ♀♀ born during the last part of June and comprising altogether 200 individuals, do not, however, breed before the beginning of August at a minimum size of 6 mm, the number of eggs being 8; these result in 800 ♂ and 800 ♀ in each of the two broods. In September the minimum size of the ♀♀ is $7_{,5}$ mm, the number of eggs 16, and the number of hatched gammarids thus altogether 1600 ♂ and 1600 ♀ in each of the two September broods. The ♀♀ of Generation II, which were born during the last half of July and which numbered 340 in all, commenced breeding about the end of August; they get therefore only 3 broods altogether; in accordance with the method of calculating employed, the 1st brood comprises in this instance also 8 eggs, the other 2 broods 16 eggs, and this gives a total of 1360 gammarids of each sex in the 1st brood and twice this number in each of the other two broods. The ♀♀ of Generation II, born during the end of July and comprising 590 individuals, hatch only 2 broods of eggs before the winter, and both of these occur during September. If every ♀ gets 8 young at a time, it amounts to 2360 ♂ and the same number of ♀ in each of the 2 broods. The ♀♀ of Generation II, born during the beginning of August, have also 2 broods of young during September. There being altogether 1100 individuals, the ♀♀ hatch in all no less than 4400 ♂ and 4400 ♀ in each brood. The 1360 ♀ of Generation II, born during the end of August, must be assumed to produce only 1 brood before October. An average production of 8 eggs gives a total result of 5440 ♂ and 5440 ♀.

Generation III comprises thus altogether 43160 ♂ and the same number of ♀; of the latter only those born before September breed. There were altogether 1050 ♀ born about the end of July; each ♀ must according to the preceding be assumed to produce in September 2 broods of young with 8 eggs in each brood; this results in 4200 ♂ and 4200 ♀ for each brood. The ♀♀ of Generation III, born at the beginning of August and amounting to 2900 individuals, have 2 broods of young during September; if each ♀ has 8 young at a time, this amounts to 11600 ♂ and the same number of ♀ in each of the two broods; finally the ♀♀ of Generation III, born about the end of August and comprising altogether 4260 individuals, get 1 brood of young in late September; when each ♀ has 8 young in this instance also, the number of young produced will be 17040 ♂ and 17040 ♀.

Generation IV, which only comprises gammarids born in September, is thus in number the largest group, as it comprises 48640 ♂ and 48640 ♀.

According to the above stated manner of calculation one pair of gammarids would in the course of 8 months have produced no less than 201 354 gammarids. Of these no less than 180 800 or $89,8\%$ are young hatched in the course of September. The remainder are adult ♂ and ♀ which, until the period of breeding

has ceased on October 1st, have been breeding from 1 to 6 times in succession; 14 gammarids, viz: the first brood of Generation I, must be assumed to have died off already in August, and it is possible that 20 others, viz: the second brood of Generation I have died off in September; but in reference to all the others it must be said that, according to the investigations made, they may very well be assumed to live throughout the winter and thereupon resume breeding activity in the next breeding period.

It is of course quite obvious that such a large production, which, if it were allowed to proceed to its full extent, would very soon fill the Danish waters with innumerous swarms of gammarids, in the free nature is restrained by a great number of facts. Amongst these the attacks of the fish must be placed foremost. The newly hatched young are devoured by nearly all kinds of young fish, those a little older by stickleback, needle-fish, fifteen-spined stickleback and other small fish of the *Zostera* region. The full-grown are taken by the cod, eel, viviparous blenny, flounder and other fish (see p. 72 in Rep. from the Danish Biological Station, XXII, 1914). It stands therefore to reason that the stock to be found per sq. metre never reaches a high figure; in order to judge these conditions I have made some quantitative investigations, which shall be described in the following.

The Size of Production.

A: In the Aquaria.

On August 2nd 1917 a stock of *Gammarus locusta*, taken from *Mytilus* by the pier of the Biological Station at Nyborg Fjord, was introduced into one of the large cement aquaria, the base of which measured 1 sq. metre, this having been filled with pure water from the Fjord. Another stock, estimated to be equal to the foregoing, was collected from the same place, and after having been killed, was measured and weighed. During the time the observations lasted, the gammarids in the aquarium were fed with food-portions of certain weight, comprising partly fresh algæ (especially *Ulva* and green thread-algæ) and partly fresh *Mytilus edulis*. On September 29th 1917 all the gammarids were taken out of the aquarium; half of the stock was weighed off and returned into the aquarium, while the other half was preserved in alcohol to be measured and weighed later on. It was proved here, as in the case of several other measurements taken later, that the rough-weight (the weight of live, wet gammarids) was about equal to the alcohol weight (the weight of gammarids preserved in alcohol). On April 25th 1918 all the gammarids were again taken out of the aquarium, and after being measured in a live state, they were thereupon returned to the aquarium. This process was repeated on June 20th 1918, and the observations were then completed on September 23rd 1918 by all the gammarids being taken out and preserved in alcohol.

The list below gives a view of the result obtained of the various measurements and weighings. It will be noted that while the measurements of August 2nd 1917 show a large group of breeding females there remained on September

mm	2/8 1917					29/9 1917					25/4 1918					20/6 1918					23/9 1918				
	♂	♀ w. eggs	♀ no eggs	Young	Total	♂	♀ w. eggs	♀ no eggs	Young	Total	♂	♀ w. eggs	♀ no eggs	Young	Total	♂	♀ w. eggs	♀ no eggs	Young	Total	♂	♀ w. eggs	♀ no eggs	Young	Total
2	—	—	—	—	—	—	—	—	1	1	—	—	—	19	19	—	—	—	—	—	—	—	—	—	—
3	—	—	—	2	2	—	—	—	12	12	—	—	—	60	60	—	—	—	60	60	—	—	—	1	1
4	—	—	—	14	14	—	—	—	8	8	—	—	—	21	21	—	—	—	141	141	—	—	—	4	4
5	—	—	—	60	60	—	—	—	4	4	—	—	—	—	—	—	—	—	171	171	—	—	—	15	15
6	—	—	—	66	66	—	—	—	3	3	—	—	—	—	—	—	—	—	138	138	—	—	—	29	29
7	—	—	—	23	23	—	—	—	4	4	—	—	—	2	2	—	—	—	93	93	—	—	—	38	38
8	1	6	2	3	12	—	—	—	1	1	—	—	—	6	6	—	—	—	42	42	—	—	1	47	48
9	20	18	6	—	44	1	—	1	—	2	—	—	—	10	10	—	—	—	39	39	2	—	2	55	59
10	36	28	7	—	71	—	—	7	—	7	—	1	2	5	8	—	—	—	30	30	4	—	5	92	101
11	61	14	—	—	75	—	—	7	—	7	—	2	—	3	5	—	1	3	33	37	11	—	22	49	82
12	48	5	—	—	53	2	1	19	—	22	—	7	3	—	10	—	3	3	3	9	23	—	33	25	81
13	5	—	—	—	5	8	—	39	—	47	1	10	1	—	12	3	3	6	—	12	16	—	22	5	43
14	—	—	—	—	—	14	—	29	—	43	4	6	1	—	11	4	4	7	—	15	12	1	6	—	19
15	—	—	—	—	—	21	—	24	—	45	3	13		—	16	3	11	10	—	24	5	—	1	—	6
16	—	—	—	—	—	39	—	15	—	54	3	10	1	—	14	5	3	10	—	18	3	—	—	—	3
17	—	—	—	—	—	38	—	8	—	46	3	6	1	—	10	5	7	5	—	17	2	—	—	—	2
18	—	—	—	—	—	19	—	7	—	26	7	6	1	—	14	3	2	2	—	7	2	—	—	—	2
19	—	—	—	—	—	14	—	—	—	14	8	9	1	—	18	4	4	3	—	11	1	—	—	—	1
20	—	—	—	—	—	5	—	—	—	5	2	16	2	—	20	12	4	2	—	18					
21	—	—	—	—	—	2	—	—	—	2	3	8	1	—	12	6	2	6	—	14					
22	—	—	—	—	—	—	—	—	—	—	5	4	—	—	9	8	—	2	—	10					
23	—	—	—	—	—	—	—	—	—	—	5	1	—	—	6	6	—	1	—	7					
24	—	—	—	—	—	—	—	—	—	—	10	2	—	—	12	7	—	1	—	8					
25	—	—	—	—	—	—	—	—	—	—	13	3	1	—	17	9	—	3	—	12					
26	—	—	—	—	—	—	—	—	—	—	10	1	—	—	11	7	—	1	—	8					
27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	5					
28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—					
29	—	—	—	—	—	—	—	—	—	—	3	—	—	—	3	—	—	—	—	—					
30	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	1	—	—	—	1					
31	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1										
32																									
Total	171	71	15	168	425	163	1	156	33	353	82	105	15	126	328	88	44	65	750	947	81	1	92	360	534
Average size in mm	$10_{,88}$	$9_{,02}$	$9_{,33}$	$5_{,61}$	$8_{,58}$	$16_{,37}$	$12_{,00}$	$13_{,81}$	$4_{,36}$	$14_{,21}$	$21_{,85}$	$17_{,28}$	$15_{,93}$	$4_{,26}$	$13_{,36}$	$21_{,08}$	$10_{,09}$	$16_{,78}$	$5_{,95}$	$8_{,57}$	$12_{,88}$	$14_{,00}$	$11_{,05}$	$8_{,97}$	$10_{,08}$
Weight in g	$4_{,12}$	$1_{,15}$	$0_{,12}$	$1_{,12}$	$7_{,11}$	$12_{,14}$	$0_{,05}$	$9_{,10}$	$0_{,1}$	$21_{,56}$	—	—	—	—	$27_{,18}$	—	—	—	—	$38_{,10}$	$3_{,75}$	$0_{,05}$	$3_{,15}$	$7_{,18}$	$14_{,19}$

29th 1917 only one breeding female; the breeding period has thus terminated. There were not very many newly-hatched young to be found, but on the other hand it is evident that a number of the smallest individuals included in columns „♂“ and „♀ no eggs“ are born in the aquarium, when taking into consideration that the measurements of September 29th comprised only one half of the gammarids, which at that time were to be found in the aquarium, and for this reason the number and weight in the list of September 29th ought to be multiplied by 2 before a comparison with the list of August 2nd can be made. Furthermore 44 adult males and 27 adult females had been gathered in the intermediate time as dead; the total weight of these was 4,₂ g. Upon adding these figures to the doubled total of September 29th, the result we obtain is that 425 gammarids, which were introduced into the aquarium on August 2nd, have during two months increased to about 777 gammarids, and that the original weight of 7,₁ g is augmented to 47,₃ g. Thus the number of gammarids has increased with about 350 individuals, and at the same time the weight of the entire stock is more than six times the original. During these two months the gammarids have increased considerably in size, and notwithstanding the appearance of young, the average length of the whole stock has increased with nearly 6 mm, viz: from 8,₅₈ mm to 14,₂₁ mm. A comparison with the September curve in fig. 1 will show that the average size of males and females from the aquarium is more than 4 mm above the corresponding figure relating to the open air. This growth is probably affected at the cost of the breeding activity, as an increment of abt. 350 young only means the hatching of 5 young in the course of two months by each breeding female, there being on August 2nd 71 such individuals.

During the first part of the winter no young appeared; the first egg-bearing females were noticed in the aquarium about the end of January, and when the whole stock was taken out of the aquarium on April 25th for examination, it was seen that a newly hatched batch of young, measuring abt. 2—4 mm in length, had appeared, and that furthermore nearly all the wintered females were carrying eggs or young in their incubatory pouches. In the meantime, however, abt. 100 adult gammarids (mostly male) had gradually died off; they weighed about 8,₂ g altogether. The total weight of the surviving stock was 27,₆ g; in deducting from this figure the 100 young measuring 2—4 mm in length, the weight of which can be set at 0,₂ g, it will be seen that the weight of the stock from September 29th during seven months has only increased from 21,₅₅ g to $27{,}_6+8{,}_2\div 0{,}_2 = 35{,}_6$ g, i. e. about 14 g. Corresponding hereto, the amount of food consumed was much less in this period than in the period August—September, which is treated further below.

On June 20th 1918 the stock had increased to 947 individuals weighing 38,₀ g, which is an augmentation of about 10 g during two months. Owing to my absence from the Station during the month of May, it was not possible to ascertain the number and the weight of gammarids, which in the meantime had died off; but as the average size and the weight of the adult males and females is approximately the same as in April, no figure of importance in reference hereto can come into consideration; the most of the large females are now spent.

Upon the termination of the observations on September 23rd 1918, hardly

any newly-hatched young were to be found in the aquarium, and only one female still carried eggs in its incubatory pouch. It was apparent that the whole wintered stock had died off, while the females of the summer stock have evidently not yet produced any new young, having confined themselves to growing. The average size 10,08 mm of the whole stock was thus considerably above the average size of the samples gathered in free nature, though it had not reached the same extent 14,21 mm as the stock of the aquarium on September 29th 1917. A comparison with the list of June 20th shows that many of the gammarids of the summer stock have died between June 10th and September 23rd; on the first mentioned date the group of young alone amounted to 750 individuals, and on September 23rd the whole stock amounted to only 534 individuals. At least 216 individuals have thus died off, and most probably many more, as many gammarids of the summer stock must have been born after June 20th. A production of young totalling 534 individuals gives only an average of 4 young to each of the 120 females found on April 25th.

Coincident with earlier experiments it was seen here that in an aquarium provided with a plentiful supply of animal food, the growth of the gammarids progresses quicker, whereas the breeding activity is much slower than in the free nature. A corresponding result was attained by an experiment, which was made to substantiate how many young a single pair of *Gammarus locusta* could produce in the course of a year. This experiment proceeded as follows:

On March 8th 1918 two females of the wintered stock, each measuring 17 mm in length and carrying newly-laid eggs in their incubatory pouches, were introduced into two separate reservoirs of cement, in each of which there had previously been placed some few males, likewise of the wintered stock. In the one reservoir a substantial feeding with fresh, opened *Mytilus* and algæ was given, while in the other no feeding whatever took place, but a quantity of live *Mytilus* and *Asterias* as well as algæ was placed therein. In the course of the summer all the gammarids of the wintered stock died off and the young grew up; but only those in the aquarium, in which no feeding had taken place, matured before the winter, as described in experiment XI. When the whole stock had been taken out of this aquarium on September 24th 1918 in order to be measured and weighed, there were found 61 young measuring 2-11 mm in length and weighing 1,2 g; 30 females all without eggs, 11-14 mm long and weighing 1,8 g; and finally 24 males measuring 15-20 mm in length and weighing 3,4 g. This totals 114 gammarids weighing 6,4 g. In the other aquarium there were fewer gammarids, viz: only 31 males and 78 females, but these were larger, measuring 17-24 mm and 12-16 mm and weighing 3,5 g and 5,5 g respectively, the total weight amounting to 9,0 g; the algæ in the first mentioned aquarium showed signs of having been much bitten by the gammarids, whereas in the other aquarium hardly any of the algæ had been consumed, there having been a sufficient suply of animal food. After having completed the measurements the gammarids were returned to the aquaria. On March 10th 1919 the experiment was concluded and all the gammarids taken out and killed in alcohol. In the aquarium where feeding had been performed, there were now 28 males measuring 18—30 mm in length, the average length being 25,5 mm, the total weight 5,8 g. During the intervening $5^1/_2$

months only three males have died; the average length has increased with 5 mm, viz. from 20,5 mm to 25,5 mm, the total weight with 2,3 g. Of live females there were 58, measuring 16-22 mm in length, the average being 18,66 mm, the total weight 6,0 g. During the winter months 20 females have thus died off; the surviving females were in full breeding activity, 53 of them carrying eggs or young in their incubatory pouches; 5 were spent individuals. The augmentation of weight was here only 0,5 g, but the average length had increased from 14 mm to 18,66 mm i. e. with 4,66 mm. In this aquarium the growth has thus proceeded very quickly, even when compared with the former aquarium observations (see e. g. the curves in fig. 3 p. 29).

As stated above one pair of *Gammarus locusta* have in the course of one year produced 11,8 g of breeding gammarids in this aquarium. In the other aquarium the rate of death during the winter months was very great, whether the cause of this was due to the presence of *Asterias* in the aquarium or to other prevailing conditions Only 20 individuals survived the winther, and when examined on March 10th 1919 they were found to comprise 13 adult males, 14-25 mm in length (average 20,46 mm) totalling in weight 1,7 g, and 7 adult breeding females, 15-18 mm in length (average 16,14 mm) and weighing 0,5 g. In the present instance the breeding activity of one pair of *Gammarus locusta* in the course of one year gave a final result of only 20 breeding gammarids, totalling in weight 2,2 g.

Even when excluding the worst enemies of the *Gammarus locusta* — the fish — the quantitative result of rearing these animals in aquaria does not at all correspond to the computed offspring of one pair of gammarids stated on p. 42. The reason of this is mainly due to the high rate of death in the comparatively small aquaria, and when employing larger and more adequately adapted reservoirs, this rate could most certainly be reduced considerably, and it is not at all impossible that a breeding of gammarids on a larger scale could be of some importance, as *Gammarus locusta* must be considered a most appropriate food for almost every kind of fish.

In free nature the natural food of the *Gammarus locusta* consists, as stated above p. 9, mainly of vegetable nourishment. Nevertheless the aquarium observations proved that the gammarids greatly appreciated animal food, especially the soft parts of the *Mytilus*, and that they could entirely dispense with plant food, when only a sufficient supply of animal food was obtainable. When in an aquarium containing gammarids an *Asterias rubens* had opened and sucked out a *Mytilus edulis*, the latter was immediately covered with gammarids, which eagerly gnawed off the remains left by the *Asterias* on the inner side of the shell. This fact conveyed to me the idea that the reason why the gammarids with preference seek the *Mytilus* clusters was not alone to hide, but also because they could occasionally enjoy the benefit of the *Asterias* meals upon *Mytilus edulis*. It is possible that remains of *Mytilus* and other molluscs, which upon being digested are exceedingly difficult to distinguish, more often than presumed by the intestine examinations made, form a part of the contents of the gammarid's intestines. Carrion of various animals is also eaten by the gammarids, and it is therefore not improbable that in reality animal food is of equal importance to these animals as plant food.

Corresponding to the fact that gammarids grow slower during the cold season than during the summer, the aquarium observation described in the beginning of this chapter proved that the gammarids also ate much less during the cold than during the warm season. About twice a week fresh, opened *Mytilus* upon being weighed were put into the aquarium in the shells; at the next feeding time the remains of the former lot were taken up, and the weight of the consumed *Mytilus*-flesh was determined. During the months of August and September 7,1 g of gammarids, as per list given below, consumed no less than 182,7 g *Mytilus*-flesh and 50 g algæ, thereby attaining a weight of 47,3 g (see p. 47). The joint weight of

Weight in g of consumed food and of gammarid stock in aquarium. From August 2nd 1917 till September 23rd 1918.

	August	Septbr.	Octbr.	Novbr.	Decbr.	January	February	March	April		May	June		July	August	Septbr.
									1'–25'	25'–30'		1'–20'	20'–30'			
Food { *Mytilus edulis*	89,4	93,13	36,12	25,17	11,5	13,10	21,10	26,10	16,5	9,5	41,8	73,10	39,10	89,10	68,10	31,10
Food { Algæ	20	30	62	20	20	20	20	20	20	—	50	100	—	100	46	20
Live *Gammarus locusta*	7,1 g	43,11 g	21,55 g	—	-	—	—	—	27,16 g	—	—	38,10 g	—	—	—	14,9 g
Dead *Gammarus locusta*	4,12 g		8,12 g								?			?		

the *Mytilus* and algæ was thus nearly six times larger than the weight of the gammarid-flesh produced, which amounted to 40,2 g. The figures all refer to rough weight, but as the dry matter percentage of *Gammarus locusta* as well as of *Mytilus*-flesh and fresh algæ is about 16, the proportion between the produced gammarid-flesh and the consumed food will remain unaltered, even if computed to dry matter. This proportion I have named „useful effect" and is in the present instance abt. $^1/_6$. During the period October—January the gammarids ate continually less from month to month, and thereafter the quantity of the consumed food increased slowly, but till April 25th only 149,9 g of *Mytilus* and 182 g of algæ had been consumed, this giving an average monthly consumption of abt. 21,4 g *Mytilus* and 26 g algæ. The weight of the gammarids had during the same period increased with 14,25 g. The relation of this weight to the weight of the consumed food or the „useful effect" is about $^1/_{23}$. From April 25th the rate of consumption increased again, and till June 20th there had been consumed 124,3 g *Mytilus* and 150 g algæ, averaging monthly abt. 62,2 g *Mytilus* and 75 g algæ. At the same time the weight of the gammarids augmented with about 10 g, this giving a „useful effect" of only $^1/_{27}$. From June 20th till the conclusion of the observations on September 23rd 227 g *Mytilns* and 166 g algæ had been consumed, averaging monthly abt. 75,7 g *Mytilus* and abt. 55 g algæ. It was impossible to ascertain the amount in grammes of gammarid-flesh produced from these quantities, as during the summer a great number of gammarids had died off, these comprising not alone the entire wintered stock but also a part of the summer stock. However,

the weight of the surviving gammarids may be reckoned as a minimum value, representing the entire production of gammarids during the period that has elapsed; it amounts to 14,9 g or $^1/_{26}$th of the weight of the food submitted.

In the course of a little more than a year — from August 2nd 1917 till September 23rd 1918 — 683,9 g *Mytilus* and 548 g algæ have been consumed. The production attained by this food in an aquarium with a base measuring 1 sq. m amounts altogether to 40,2 + 14,25 + 10 + 14,9 = 79,35 g gammarids or about $^1/_{16}$ of the aggregated weight of the food. It must continually be taken into consideration that the figure representing the production of gammarids is a minimum value. The fact is however certain that such a violent growth and augmentation of weight in the stock of gammarids as took place in the aquarium during the months of August and September 1917, was not followed by a similar increasement in the months of August and September 1918; this must be due to the existance of certain restraining factors in the aquarium, in first instance most probably the attack of bacteria, to which gammarids are susceptible when living for a longer period in an aquarium. The facts derived from the above show that during winter the gammarids consume only about $^1/_3$ of the quantity, which they devour during the summer, a fact which explains their comparatively slow growth during the cold season.

In the aquarium experiment described page 48, one gammarid female produced in the course of $6^3/_4$ months — March 8th till September 29th — 9 g of young. During this period 43 g of *Mytilus*-flesh had been given; the amount of algæ consumed was so inconsiderable that it could not be measured. As it must be supposed that the parent gammarids, which upon introduction into the aquarium weighed 0,5 g and did not die off before July, have consumed their share of the food, the above mentioned 43 g *Mytilus*-flesh gives a minimum production of 9 g gammarids, which means a „useful effect" of more than $^1/_5$ of the food given. During the winter months 24 gammarids, weighing 2,6 g, died off. On March 10th 1919 the remaining stock, comprising 86 gammarids, weighed 11,8 g. From September 20th till March 10th 65,5 g *Mytilus*-flesh was given, and the gammarid-flesh produced from this amounted to 11,8 + 2,6 ÷ 9,0 = 5,4 g i. e. a „useful effect" of abt. $^1/_{12}$ of the food given. For the whole year the „useful effect" amounted to $\frac{14,4}{108,75}$ = abt. $^1/_8$.

Even if we cannot disregard the Detritus, which always gathers at the bottom of the aquaria, notwithstanding their being fitted with lids (amongst other reasons to prevent the algæ placed therein as food in growing) and which to some extent may have served as food for at any rate the smallest gammarids, the nourishment can only to a slight degree be presumed to originate from other sources than the weighed food introduced into the aquarium. It is therefore not unwarranted to emphasize that the experiments made here with weighed food show that the proportion between the augmentation of weight of the gammarids and amount of consumed food in the aquaria varies between $^1/_5$ and $^1/_{27}$, as minimum value; this proportion was greatest shortly after the gammarids were introduced into the aquaria; it decreased somewhat during the winter and was smallest in the case of the adult gammarids, which

had been the longest time in the aquarium. For a whole year the figures concerning the two experiments were respectively $^1/_8$ and $^1/_{16}$. In the Report of the Biological Station, No. XXV (C. G. Joh. Petersen (19) 1918, p. 22) it is assumed that the fish as well as the predatory animals among crayfish, gastropods and polychaeta require 10 kg food to produce 1 kg flesh; the figures obtained through the present experiments tend to prove that the estimated figures are not very wrong.

B. In the Nyborg Fjord.

In order to gain some idea as to the amount of *Gammarus locusta* which an area of water as Nyborg Fjord contains, I have during a whole year made a number of quantitative investigations of the stock of gammarids, partly from clusters of *Mytilus* and partly from shallow waters close to the shore among algæ and similar plants.

The samples from *Mytilus* are taken from the aforesaid place by the outer pier of Nyborg harbour, where there was a large old stock of *Mytilus*; on each occasion 12 litres or 11,5 kilos of *Mytilus* were gathered, this quantity covering on an average an area of about 1,5 sq. metre. All the gammarids found among these *Mytilus* were picked out, measured and weighed. The measurements are partly included in table 1, the weights are to be found in the table given below.

Rough weight of Gammarus locusta from 11,5 kg Mytilus or abt. 1,5 sq. m pier surface.

Pier of Nyborg harbour 1916—1918.

year	date	♂	♀ w. eggs or young	♀ no eggs or young	young	total
		g	g	g	g	g
1916	4/8	2,10	0,18	2,12	1,12	6,12
	8/9	3,15	0,15	4,16	2,17	11,13
	28/9	3,15	0,11	7,1	1,10	12,16
	4/11	3,10	0	2,9	0,2	6,1
	21/11	6,13	0,12	7,10	0,16	14,11
1917	15/2	7,15	4,15	1,13	0	13,13
	14/4	8,11	5,10	0,11	0	13,12
	7/6	3,18	3,13	0,15	1,10	8,16
	4/7	17,18	7,14	12,17	26,12	64,11
	15/8	9,15	3,10	2,15	15,10	30,10
	15/9	8,10	0,14	9,16	8,15	26,15
	3/10	6,11	0	4,19	14,10	25,10
	20/11	3,12	0,11	1,10	0,14	4,17
1918	21/1	2,12	1,11	1,15	0,14	5,12
	25/2	1,16	0,13	0,10	0,12	2,7
	[illegible]	6,15	3,17	4,11	0,14	14,8
	18/5	5,19	7,13	1,15	7,16	22,13

It will be noted that though the figures vary greatly, there is no doubt but that the stock is largest during the summer and smallest during the months of November—February. The highest figure found relates to July 4th 1917 and is 64,1 g. A sample taken from this large stock was measured, and the measurements obtained are to be found in table 1. It will be seen from this that all the gammarids, with perhaps one exception (a male measuring 18 mm in length), according to their size must belong to the summer stock; they are thus young gammarids, which have not yet reached their full size and weight. They are not fully developed before the following spring, but as will be seen from the figures of the table given above, there are at this time of the year only a very few gammarids left. The *Gammarus locusta* being an annual animal, we can, however, use the highest figure found, which is the figure for July 1917, as minimum value for the annual production of gammarids among *Mytilus*. This will therefore be $64{,}1 \times {}^{2}/_{3} = 42{,}7$ g per sq. metre. (All the weights mentioned in this chapter are rough weights).

The examination of the shallow water, overgrown with plants, was made in the neighbourhood of the anchorage of the Biological Station by means of a fine-meshed hand-net with a high, rectangular frame, the lower side of which was 0,5 metre wide (described in the Report of the Biological Station XXV, 1918, p. 39). By means of this net a predetermined area of the plant region could be treated, as a 2 m long drag covered an area of 1 sq. m, a 4 m long drag 2 sq. m etc. It was soon noticed that the surface of the water, which during the daytime did not contain very many gammarids, was crowded with gammarids as soon as it became dark, but these gammarids were mostly very small, newly hatched young, which were easy to catch with the hand-net. It was furthermore noticed that the dragging of the hand-net through algæ was most profitable after dark. This would suggest that the gammarids, for fear of their numerous enemies, during the daytime hide among the roots of the plants, where the hand-net cannot reach them, and during the night come out in searh of live food, especially Copepoda, of which remains are often found in the intestines of the gammarids. The gammarids were

Number and weight in grammes of Gammarus locusta per sq. m caught with quantitative hand-net in the Nyborg Fjord 1917—1918.

Place	Algæ		Water surface	Algæ		Water surface	Algæ	Water surface	Algæ			
Date	$^{17}/_{4}$ 1917	$^{5}/_{6}$ 1917	$^{7}/_{6}$ 1918	$^{23}/_{6}$ 1917		$^{31}/_{7}$ 1918	$^{16}/_{8}$ 1917	$^{22}/_{8}$ 1917	$^{2}/_{9}$ 1917	$^{26}/_{11}$ 1917	$^{22}/_{1}$ 1917
	p. m.	p. m.	Evening	noon	Evening	Evening	Evening	Evening	Evening	p. m.	p. m.
Area treated	$27{,}5$ m²	2 m²	1 m²	1 m²	1 m²	2 m²	1 m²	2 m²	1 m²	1 m²	2 m²
Number per sq. m...	4	0	23	180	632	300	311	100	154	2	0
Rough weight in g per sq. m	$0{,}^{m}1$	0	$0{,}_{14}$	$1{,}_{10}$	$3{,}_{80}$	$1{,}_{59}$	$1{,}_{23}$	$0{,}_{48}$	$0{,}_{56}$	$0{,}_{02}$	0

easy to attract by means of a light; they would gather in great numbers below it, often accompanied by young of *Mysis*, *Idothea* and *Crangon*, crab larvae, *Nereidæ* in mating dress as well as young of various fish, especially the young of goby and stickleback. The swarming of gammarids after dark agrees very well with the fact that many of the most eager consumers of gammarids amongst the fish, as I have proved in my report (4, 1917, p. 35) do not take food during the night. The present table comprises the results of several quantitative draggings performed partly through algæ at a certain point by the pier of the Biological Station, a trial having proved this place to be a good representative of the conditions in the shallow waters of the Nyborg Fjord, and partly through the surface water by the anchorage of the Station. It is noticeable that considerable quantities of gammarids per sq. m are only to be found during the summer months; during the winter the greater part of these animals hide among *Mytilus*, stones, dead sea-weed and the like.

All the gammarids caught in the hand-net being very small and not more than a month old, it can be supposed without reckoning too high, that the aggregation of the highest of each of the monthly weight-figures gives a minimum value of the entire annual production. This value amounts thus to: $0{,}01 + 0{,}14 + 3{,}30 + 1{,}59 + 1{,}23 + 0{,}56 + 0{,}02 = 6{,}85$ g per sq. m.

The Nyborg Fjord covers an area of about 1800 ha and of this abt. 500 ha have less than 5 m water above the bottom. Surmising that gammarids are to be found in this part only of the Nyborg Fjord, and that $^1/_{10}$ of the area is covered with *Mytilus*, stones, etc., and thus, in accordance with the above stated, yields a production of gammarids amounting to $42{,}7$ g per sq. m, while the remaining part of the area produces $6{,}85$ g gammarids annually, the result we obtain is that the annual production of gammarids in the Nyborg Fjord averages abt. 10 g per sq. m, or a total production of abt. 50000 kilos. This figure is, however, most certainly too low. If thus only one half of the 632 individuals, which on June 23rd 1917 were found on each sq. m. amongst the algæ of the shallow water, survive the winter they will reach a weight of more than 15 g, as, in the month of April 274 wintered individuals, according to the table p. 52, weighed $13{,}2$ g; a production of 15 g per sq. m would thus result in an annual production of 75000 kilos in the whole of the Nyborg Fjord. In reality it is quite impossible to ascertain whether these figures shall be doubled or three-doubled, as owing to the impetuous persecution the gammarids are subject to, the stock is daily reduced with immense numbers of individuals, of which we have neither number nor quantity.

Whether or nor the figures arrived at be approximately correct, the present investigations have at any rate contributed to make clear the exceedingly strange circumstance that so many fish live almost solely on gammarids, while at the same time the current stock of these animals in nature is so very small. When the production of a single pair of *Gammarus locusta* in the course of five months can amount to hundred of thousand, it is easily understood that considerable quantities can be yielded every year as food for other animals, and that a surplus still remains to maintain the stock. The offspring of one pair of *Gammarus locusta* as calculated page 42 would in October weigh about 2 kilos, this figure based upon the weight of the 2437 individuals measured on October 3rd 1917 (see page 52). Reckoning

with a „useful effect" of $^1/_{10}$, the offspring of one pair of *Gammarus locusta*, if they all lived until the month of October, could thus be turned into no less than 200 g fish-food.

Other Species of Amphipods.

The 11 species of amphipods mentioned page 9 and which occasionally have been caught together with *Gammarus locusta*, I have not examined in aquaria, but certain conditions tend to show that in their biology they correspond to *Gammarus locusta*. In April only large breeding individuals and newly-hatched young were found, whereas later on in the summer only small individuals were seen, a part of these carrying eggs or young in their incubatory pouches. The fact that the same ♀ individual was able to hatch more than one brood of eggs was pointed out in the case of several of the species, it being noticed that in ♀♀ carrying well developed eggs or young in their incubatory pouches, large eggs could be distinguished in their ovaries. The most common species was *Calliopius Rathkei*, which was found amongst both *Mytilus* and algæ, and simultaneously with the young of *Gammarus locusta* this species could often be found in myriads filling the surface of the water during quiet nights.

To serve as comparison with Haempel's (11) and Dahl's (5) observations on the biological conditions in Bavaria and Norway of *Gammarus pulex*, I have kept 4 ♀ and 3 ♂ of this species in an aquarium. They were caught in a stream in the vicinity of Nyborg on April 19th 1918; all the females had on being caught eggs in their incubatory pouches. They were introduced into an aquarium containing well-water, and they were fed with fresh-water plants and a little *Mytilus*-flesh. On May 14th 1918 one of the ♀♀ died after having had a new brood of eggs on April 24th; 2 of the others died on June 10th 1918, also after having had at least two new broods of eggs; the last ♀ died on June 31st 1918 after having had at least 3 broods of eggs, viz. besides the brood it had upon being placed in the aquarium, a second brood on May 10th and a third brood on June 21st. The period of incubation lasted about 20 days. The last ♂ died on September 13th 1918; unfortunately it was not possible to keep the produced young alive in the aquarium, and it was therefore not either possible to ascertain whether these young could mature before the winter. The experiment shows, however, that each *Gammarus pulex*-♀, as is the case of *Gammarus locusta*, can produce several broods of eggs in the same breeding period, and it is therefore reasonable to surmise that these two species, which resemble each other so closely, are identically related in reference to the production of several generations annually. In common with *Gammarus locusta* the *Gammarus pulex* does not seem to breed during the cold season here, as I have never found eggs in the incubatory pouch of this species during the winter.

Resumé.

The *Gammarus locusta* is annual. The period of breeding lasts from the end of January till some time in October. The larger of those individuals, which live throughout the winter — the winter-stock — reach maturity about the end of January; in April the whole winter-stock is mature, and each ♀ may hatch up to 7 broods of young. The wintered individuals die off in the course of June and July; by the end of July the winter-stock has completely died off. The winter-stock produces 4 generations of young; Generation I is born in the course of March–July; all the individuals of this generation reach maturity before the winter. Generation II appears during May–September, and Generation III during July-September. Of these generations only the gammarids, which are born before September, reach maturity the same year. None of the individuals of Generation IV, which are all born in the course of September, reach maturity before the winter, Generations I–IV indicate the summer-stock of the year; each ♀ of this stock may lay up to 7 broods of eggs in the course of one breeding period, but all the individuals, which are born before May, may be assumed to die off before the winter; the remaining gammarids of the summer-stock may, according to the aquarium observations made, after having survived the winter, resume breeding at the beginning of the subsequent breeding period.

The period of incubation varies with the temperature of the water. During the warm season it lasts only 11 to 12 days, but at the commencement of the breeding period it lasts about one month. Subsequent to every hatching in the breeding period a new oviposition takes place immediately.

The growth (fig. 3) proceeds more slowly during the winter than during the summer. The males grow quicker and become larger than the females. Maturity is reached quickest in the case of those gammarids, which are born during the warmest summer time, whereas those gammarids, which are born in the beginning of a breeding period, were more than 2 months old, before they matured. In accordance herewith the gammarids of the summer-stock always matured when of a much smaller size than the gammarids of the winter-stock, and on account of this fact alone, they were easily distinguishable from these.

Mating (fig. 5) takes place immediately after the completion of the hatching of eggs and the subsequent moulting of the ♀. Several days before the mating takes place, the ♂ seizes a ♀ („riding-position", fig. 4) and does not release its hold before the mating is completed.

The number of eggs which each ♀ lays is partly dependent upon the size of the gammarid in question and partly upon the temperature of the water, the number of eggs increasing with both of these facts. See the table page 40.

In accordance with calculations made, one pair of *Gammarus locusta* of the winter-stock would, in the course of one breeding period, be able to produce an offspring amounting to more than 200000 individuals (p. 42). This figure will, however, never be reached in the free nature, as the gammarids are some of the most desired animals; they are devoured in huge quantities especially by the fish. The greatest number of young produced by a pair of gammarids in aquarium

was 114. In the Nyborg Fjord the annual production may be estimated at about 10—15 g (rough weight) pr. sq. metre (p. 54).

The food is partly detritus and partly fresh plant food and animal food. The *Gammarus locusta* is easily kept in aquarium when fed with the meat of *Mytilus edulis* and algæ. It has been proved that the animals in the aquarium eat less during the winter than during the summer. Feeding experiments have substantiated that the „useful effect", i. e. the relation between the increasement in weight of the gammarids and the amount of food consumed, varies between $^1/_5$ and $^1/_{27}$ (p. 51).

In comparison with amphipods from other countries, our *Gammarus locusta* corresponds in reference to biological conditions nearest with the three American gammarid species examined by Embody. It occupies an intermediate position between the Norwegian *Gammarus pulex,* examined by Dahl, on the one side, and the Bavarian *Gammarus pulex,* examined by Haempel, and the English *Gammarus chevreuxi,* examined by Sexton & Matthews, on the other side. All the observations hitherto made tend to prove that the temperature is one of the most important biological factors in the life of the amphipod; it is therefore very probable that a suitable feeding and breeding of *Gammarus locusta* in shallow reservoirs would be profitable during the warm time of the year, as this animal is an excellent food-object for fish.

Mysids *(Mysidæ).*

The most frequent mysids in the Nyborg Fjord are the three species *Mysis flexuosa* O. F. Müller, *Mysis neglecta* G. O. Sars and *Mysis inermis* Rathke; less frequent are *Mysis vulgaris* Thompson, *Mysis spiritus* Norm., and *Macropsis slabberi* v. Beneden. Immediately outside the Fjord *Mysis mixta* is found in great numbers in the deep water of the Great Belt, where *Gastrosaccus spinifer* Goës is also found on the sea bottom.

In opposition to *Gammarus locusta,* the life of which is closely related to the sea bottom, plants, *Mytilus,* stones etc., while only the younger individuals especially during the night move freely about in the surface of the water, the above mentioned species of mysids (excepting perhaps *Gastrosaccus spinifer)* are swimming animals all their life, and seldom rest for a moment on the leaf of a *Zostera* or algæ; if they are pursued, they try to save themselves like the shrimps by hopping backwards through the water in long leaps, which they perform by suddenly drawing the tail in against the body. When they are not disturbed, they flock together in larger or smaller numbers, keeping float almost in the same spot by means of quick whirling movements of the peraeopods with their well developed

exopodits. In such a flock both small and large individuals of the same species will often be found, but different *Mysis*-species are seldom found together in the same flock.

Of the three most common species, the largest and the least pigmented species, *Mysis flexuosa*, usually keeps to the open sand spots among the *Zostera* close to the shore, whereas *Mysis neglecta*, which is pigmented to a much higher degree, lives among the plants and *Zostera* and goes usually to much deeper water than *flexuosa*. The smallest species, *Mysis inermis*, goes out to the deepest water. All three species are closely related to the plant region of the *Macoma*-community and are not to be found on the soft, bare sea bottom outside this. The contents of their intestines always consisted of a fine detritus-mass, most essentially comprising more or less fresh remains of plants, amongst which were often found remnants of copepoda, ostracoda and similar small crustaceans, or of pelagic lamellibranch and gastropod larvæ. In the aquaria they devour mussel-flesh with eagerness; when they have got attentive of a piece of mytilus-flesh (as it seems especially by means of their long and constantly moving antennæ), they dart at it, and then with a sudden pull tear a little piece off and devour it while floating in the water. The mysids must therefore be considered as plant- and detritus-eaters, as well as carnivorous animals (see furthermore Blegvad (4), 1914, p. 70—71).

There are no difficulties in distinguishing *Mysis inermis* from the two other species, as even the smallest young may immediately be recognized by their short and broad antennæ plates, but to distinguish *Mysis flexuosa* from *neglecta* affords greater difficulty, and in the case of the smallest young is often quite impossible. The most common distinction marks (see e. g. K. Stephensen: Skjoldkrebs. Danmarks Fauna. 9. 1910) are the shape of the antennæ plates, which in fhe case of *neglecta* shall only be 5 times the breadth in length, and in the case of *flexuosa* 7—8 times the breadth in length, and furthermore the number of spines on the tail plate, which in reference to the first named shall be 18—20 and with the latter 21—27. The first of these two distinction marks is without value when treating a large material, as it is impossible, even with the aid of a binocular microscope, to measure by the eye how many times an antenna plate is longer than broad; and furthermore the shape of the antenna plate changes with the age. In order to test the other distinction mark, I have counted the spines of the tail plates of 100 true *flexuosa* and 100 true *neglecta*, all half grown or adult individuals from the Nyborg Fjord, April 1917.

The result was as follows:

♂

Length of anim. in mm	Number of spines on tail-plate						
	21	22	23	24	25	26	27
12	—	1	1	—	—	—	—
13	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—
15	1	—	3	—	—	—	—
16	—	2	—	—	—	—	—
17	—	1	—	4	—	—	—
18	—	1	1	2	3	1	—
19	—	1	3	5	5	1	2
20	—	—	3	3	1	—	2
21	—	—	—	1	1	1	—
22	—	—	—	—	—	—	—
23	—	—	—	—	—	—	—
	1	6	11	15	10	3	4

Average: $24_{,08}$ spines.

♀

Length of anim. in mm	Number of spines on tail-plate						
	22	23	24	25	26	27	28
12	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—
15	—	—	—	1	—	—	—
16	—	1	—	—	—	—	—
17	—	1	—	—	—	—	—
18	1	5	1	1	—	—	—
19	1	1	2	3	1	—	—
20	1	3	3	4	—	—	1
21	1	3	3	3	1	—	—
22	—	1	4	-	-	—	
23	—	—	2	1	—	—	—
	4	15	15	13	2		1

Average: $23_{,92}$ spines.

Mysis flexuosa.

♂

Length of animal in mm	Number of spines on tail-plate				
	17	18	19	20	21
10	—	1	—	—	1
11	—	—	2	—	—
12	—	—	—	—	—
13	—	1	1	—	—
14	—	3	2	2	—
15	—	5	5	2	—
16	2	4	3	—	—
17	—	1	—	1	—
18	—	—	—	—	—
19	—	—	—	—	—
	2	15	13	5	1

Average: $18_{,7}$ spines.

♀

Length of animal in mm	Number of spines on tail-plate					
	17	18	19	20	21	22
10	—	—	—	—	—	—
11	—	1	—	1	1	—
12	—	—	1	—	—	—
13	—	—	—	—	1	—
14	—	—	2	3	—	—
15	—	4	2	6	1	—
16	2	3	3	4	3	—
17	2	3	2	5	3	2
18	1	—	5	—	1	1
19	—	—	—	—	—	1
	5	11	15	19	10	4

Average: $19_{,5}$ spines.

Mysis neglecta.

It must be noted that in some cases there were about 3 spines more on the one side of the tail-plate than on the other; in such cases the largest number of spines is set down in the tables.

As will be observed there is a considerable overlapping in the figures, as no less than 15 % of the examined *neglecta* have more than 20 spines. Regarding

flexuosa, the average number of spines is about equal in ♂ and ♀, viz. about 24, whereas ♀♀ of *neglecta* have more than the smaller ♂♂, viz. 19,5 and 18,7 respectively. Already here in the case of *flexuosa*-♂♂ there seems to be a slight tendency of correlation between the number of spines and the total length of the animal; but still more pronounced does this circumstance become when the younger individuals are examined. Thus the result of an examination of the following 155 *Mysis flexuosa* from Slipshavn in the Nyborg Fjord, July 7th 1917, was:

Length of animal in mm	Number of spines on tail-plate																	
	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
5	1	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	2	1	1	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—
7	—	—	—	1	—	2	2	2	1	—	—	—	—	—	—	—	—	—
8	—	—	—	1	1	—	2	5	4	12	8	6	2	1	—	—	—	—
9	—	—	—	—	—	—	—	3	3	6	9	6	13	3	1	—	—	—
10	—	—	—	—	—	—	—	—	—	1	6	3	6	4	1	—	1	—
11	—	—	—	—	—	—	—	—	—	1	4	3	4	4	1	1	1	—
12	—	—	—	—	—	—	—	—	—	—	—	1	3	2	—	—	—	1
	3	4	2	4	3	2	4	10	8	20	27	19	28	14	3	1	2	1

Average: $18_{,57}$ spines.

The number of spines increase thus as the animal grows and can therefore not be used as a distinguish mark for the young individuals. On the other hand the position of the spines can often be used to advantage, as it has been observed that the spines of the *neglecta* are larger, more uniformly arranged and nearly

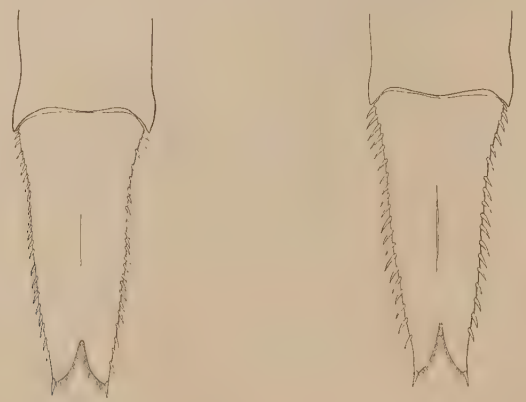


Fig. 6.
Tail-plate of *M. flexuosa* and of *M. neglecta*. × 14.

parallel to each other, whereas in the case of the *flexuosa* they are smaller and situated at irregular intervals; following the 6—7 fairly well-developed spines in the proximal part of the tail-plate there are 6—7 smaller spines pointing more upwardly

and rearwardly; after these a few more larger and well-developed, outwardly pointing spines are found (see fig. 6). The colour of the hairs on the last pair of pleopods of the living *neglecta* is always a bright violet, whereas the corresponding hairs of the *flexuosa* are mostly colourless or only very slightly coloured. Finally the elongated form of the body as well as the slight pigmentation, which is especially fouud amongst the younger individuals, often affords a good distinction mark for *flexuosa* in opposition to the short and strongly pigmented *neglecta*. By means of these distinction marks I have been enabled to determine nearly the whole material relating to the mysids; only in a few single cases (see the tables of measurements for June 25th and July 3rd 1917), which referred to newly hatched young, have I been obliged to give up separating the 2 species.

The investigations of the biology of the three *Mysis*-species may, as in the case of *Gammarus locusta*, be divided into measurement investigations, aquarium observations and investigations relating to the size of production.

Measurement Investigations.

The investigated material originates partly and most essentially from the Nyborg Fjord, and partly from other places in Denmark, being collected in the course of the years 1916—19. The measurements are taken from the front edge of the eyes to the point of the last pair of pleopods. Of 9025 *Mysis inermis* collected from the Nyborg Fjord, 28 measurements were made, and of 1942 individuals gathered from different places outside Nyborg Fjord, 12 measurements were made. As it was observed that the conditions altered very little from the one year to the next within the same season, and that they were about the same in the Nyborg Fjord as outside it, only 15 of the most complete and representative measurements from Nyborg Fjord of the two years 1917—18 are given in table 3 at the end of this book, these selected measurements giving a sufficiently clear picture of the changes, which in the course of the varying seasons take place in the size of the individuals and the composition of the stock. For the same reason table 4 includes only 16 of the 28 measurements (of 7310 individuals) which were taken of *Mysis flexuosa* collected from the Nyborg Fjord, and table 5 only 15 of the 27 measurements (of 5145 individuals) taken on the *Mysis neglecta* from the Nyborg Fjord. The column „♂" comprises all the individuals with distinctly elongated pleopods of the 4th pair, even if they had not reached their full length. The column „♀ with eggs or young" comprises all the females, which carry eggs or young in their incubatory pouch, while the column „♀ without eggs or young" comprises all the other ♀♀, as well those with small undeveloped incubatory lamellæ as spent females with large empty incubatory lamellæ. In the column „Young" all the young individuals, the sex of which it has not been possible to determine by means of exterior distinction marks, even when seen through a binocular microscope, are gathered.

As it soon became apparent that fishing at one or more certain places was

unnecessary to obtain a satisfactory representation of the stock in the Fjord, the samples used for measurement purposes were collected from different places in the Fjord. The gear employed was usually a small seine of canvas, which was dragged by a small sailing vessel. The number of measured mysids in each sample is likewise exclusively chosen in reference to obtain a correct idea of the stock of mysids at the place in question and at that time of the year; for this reason the numbers of ♂♂, ♀♀ with eggs etc. in the various samples cannot be compared directly, but have to be computed to percentage of the entire stock, as shown in figs. 7—9.

1. *Mysis inermis.*

Fig. 7 comprises graphical measurements of the *Mysis inermis* from the Nyborg Fjord in the course of a year. To the right and opposite each sample in the table the total number, the average size and the percentage of the various groups within each sample, are stated; the figures I and II indicate whether the animals belong to the winter- or the summer-stock respectively.

In February it will be observed that no breeding individuals are yet to be found. One quarter of the stock consists of „Young", as ♂♂ and ♀♀ cannot yet be distinguished from each other under the microscope. In the group „♂" there were not found any individuals with fully developed pleopods of the 4th pair, and all the ♀♀ had still only small undeveloped incubatory lamellæ.

In March 1917 no measurements were taken, but the measurements of March 1918 (table 3) show that the conditions are still about the same as in February.

In April it will be observed from fig. 7, that the breeding period has not yet commenced on April 14th; the largest ♂♂ had, however, well developed pleopods of the 4th pair and many of the ♀♀ had comparatively large incubatory lamellæ, as likewise large eggs were distinguishable in the ovaries of the largest individuals; all this clearly shows that the breeding period is now approaching. The stock as a whole has since February increased $^3/_4$ mm in length, and only 7 % of the stock are not distinguishable in reference to sex. About the end of April the breeding period commences, as a few of the largest ♀♀ then get eggs, as will be seen in the table 3 of the list for April 20—24th 1918.

In May still more ♀♀ get eggs in their incubatory pouches, as will be seen from the measurement list of table 3 for May 1918.

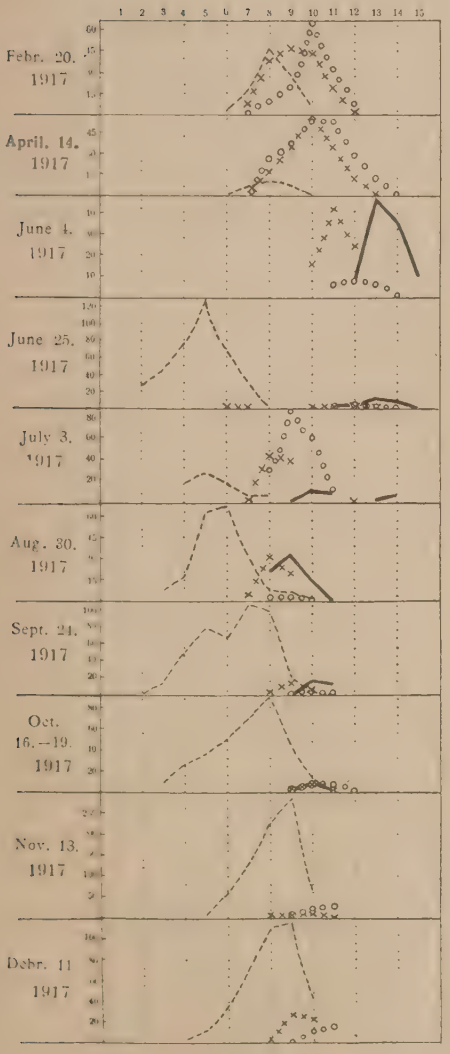
In June the breeding period has reached its climax; the measurements from June 4th 1917 (fig. 7) show that 49 % of the stock comprises egg- and young-bearing ♀♀. The young have not yet appeared (in 1918, however, a few newly hatched individuals were found after a careful search already at the end of May); the circumstance that $^2/_3$ of the ♀♀ have young in their incubatory pouches show that the hatching is immediately ensuing; all these ♀♀ have in their ovaries well developed eggs of a size corresponding to the newly laid eggs, and they are thus going to breed at least once more. The stock has increased in size with no

less than 2,4 mm since April. On June 25th fig. 7 shows that a great number of young have now been hatched; the young form a group distinctly separated from

Fig. 7. Measurements of Mysis inermis.

Nyborg Fjord, 1917.

The ordinates are number of individuals, the abscissæ their lengths in mm



Total number	♂ I G.	♂ I %	♂ II G.	♂ II %	♀ with eggs or young I G.	♀ with eggs or young I %	♀ with eggs or young II G.	♀ with eggs or young II %	♀ without eggs or young I G.	♀ without eggs or young I %	♀ without eggs or young II G.	♀ without eggs or young II %	young G.	young %
391.	9,21								10,09				8,14	
G 9,22		40								34				26
392	9,80								10,28				8,04	
G 9,97		40								53				7
199	11,41				13,50				12,10					
G. 12,39		40				49				11				
426.	11,50		6,50		13 24				12,45				4,72	
G 5,57		0,7		0,3		7				3				89
371.	12,00		8,43		13,67		10,40				9,25		5,41	
G. 8,49		0,3		21,7		2 5		5,5				50		20
342			8,21				8,33				9,00		5,78	
G 6,91				17				21				2		60
191			9,21				10,26				10,25		6,40	
G 6,83				4				6				2		88
377.			10,00		13,00		10,00				10,49		6,97	
G 7,33				2		0,3		3,7				5		89
853			9,38								10,40		8,17	
G 8,..				2								6		92
471.			9,38								10,53		8,02	
G 8,31				11								6		83

——— Young

× × × ♂

——— ♀ with eggs or young in the incubatory pouch

o o o ♀ without „ „ „ „ „ „ „ „

G = Average size in mm.

% = Number of individuals in each group expressed in percentage of the entire stock.

I = Winter-stock.

II = Summer-stock.

the others and they have already grown to an average size of nearly 5 mm. These young and the young born in the course of the summer I have, similarly with the designation of the *Gammarus locusta,* named the „summer-stock", in opposition to the wintered stock, called the „winter-stock". In fig. 7 the winter-stock is indicated by I and the summer-stock by II. There are continually to be found large breeding ♀♀ and mature ♂♂, all belonging to the winter-stock. Only 3 % of the stock comprises ♀♀ without eggs, and of these only one is a spent ♀, the remainder not yet having reached maturity. A corresponding picture is obtained from the measurements taken on June 22nd 1916, where only 3 ♀ of a stock numbering 406 individuals were without eggs, and these three were all spent individuals with large empty incubatory pouches. The newly hatched young measure 2 mm.

Referring to the next measurement curve for July 3rd 1917, we note that there are now two easily distinguishable groups of breeding mysids, viz. of ♀♀, one small group of an average length of 13,67 mm and a somewhat more numerous group of an average length of 10,4 mm.; of ♂♂ the corresponding figures are 12,0 mm and 8,43 mm. There is thus a group of large and a group of small breeding mysids; the first named group comprises the remains of the winter-stock, while the latter comprises the individuals of the summer-stock, which have now reached maturity; the only distinction between them is that the colour of the summer-stock is lighter than that of the winter-stock, which is evidently about to die off, and to which only 2 % of the entire stock belong; the fact that of 371 individuals measured there is only one ♂ but 9 ♀ of the winter-stock, tends to prove that the ♂♂ die off first. That the small breeding ♂♂ and ♀♀ really belong to the summer-stock is evident from their colour as well as from their small size, for in June there were found no ♀♀ of the winter-stock measuring less than 11 mm and no ♂♂ less than 10 mm in length; accordingly the mentioned small mature mysids, the ♀♀ of which average 10,4 mm in length and the ♂♂ only 8,43 mm, must belong to the summer-stock. Likewise the table shows that the group of young, which in June comprised 89 % of the entire stock, now only represents 20 %, which is due to a number of the individuals of this group having reached maturity in the meantime. None of the breeding ♀♀ of the summer-stock had well-developed young in their incubatory pouch; the most of them had eggs, a few of them slightly developed embryos, which had recently broken the egg-shells; the breeding period of the summer-stock has thus just commenced. The sample contains no newly hatched young, owing to the fact that the winter-stock is about to disappear and the summer-stock has not yet hatched any young.

The sample for August 30th 1917 shows that there have now appeared still more breeding ♀♀ of the summer-stock, especially of the smaller individuals, and the average size of the ♀♀ with eggs is thereby reduced to 8,93 mm. Of the winter-stock there are none left, but a new large group of young has appeared, viz. the young hatched by the summer-stock; this group comprises 60 % of the entire stock. The curve relating to the young continues to the right far into the curves of the adult mysids. It was possible to substantiate in the same manner as described above, that the ♀♀ of the summer-stock also breed twice.

The curves of measurement for September 24th 1917 still show a number of breeding ♀♀ of the summer-stock, but they form now only 6 % of the entire stock.

There is continually a very large group of young which comprises no less than 88 % of the whole material.

On October 16th—19th the breeding period is nearly at an end, only 4 % of the stock being breeding ♀♀, and nearly all of these have young — not eggs — in their incubatory pouches. The few ♀♀ without eggs are spent individuals with large, strangely collapsed incubatory lamellæ; neither these nor the ♀♀ carrying young have developed eggs in their ovaries. The increase in the average size of the stock as a whole shows also that practically no more young are produced. Strange enough a single breeding ♀ measuring 13 mm, and which undoubtedly belongs to the winter-stock has been found so late in the year.

In the sample of November 1917 no more breeding ♀♀ are to be found. The average size of the stock has increased with 1 mm, and the young form no less than 92 % of the entire stock; nearly all the ♂♂ have only undeveloped pleopods of the 4th pair, and the few ♀♀ without eggs have all small incubatory lamellæ.

In December conditions were about unaltered. The stock as a whole has not increased perceptibly in length; there are, however, comparatively few young, because the largest individuals can now be determined as to sex, though they are still far from fully developed.

The sample from January 1918 (see table 4), in which still more individuals — especially ♂♂ — could be determined in reference to sex, forms a transition to the condition in February already described. *Mysis inermis* does thus not breed throughout the winter.

As mentioned above the measurements made in the other years of 1916—1919 indicate that the conditions described for a single year are repeated from year to year in the Nyborg Fjord. Measurements from other places than the Nyborg Fjord (different places in the Limfjord, the Kerteminde Fjord, Svendborg Sound) show too that the conditions are the same everywhere in all the investigated waters. The only difference is that *Mysis inermis* becomes about 2 mm longer in the Limfjord than in Nyborg Fjord; thus the figures representing females with eggs in a measurement from Sundby Hage by Aalborg on July 20th 1916, formed a fine two-crested curve with maxima at 12 mm and 15 mm, there being at this time breeding ♀♀ of the summer-stock (average size abt. 12 mm) as well as of the winter-stock (average size abt. 15 mm).

The results of the measurement investigations are shortly the following:

Mysis inermis is at the highest annual, because the wintered stock dies off every year during the months July—August. The breeding period lasts from late April until late October, the winter-stock breeding from late April until it gradually dies off, the summer-stock breeding from the beginning of July until late October. The period of incubation for the broods hatched early in the year is about 1 month, the first young appearing about the end of May. It was evident from the large ovarial eggs that each ♀ was able to breed several times, the eggs being most prominent with the ♀♀ thatcarried young in a very advanced stage of development in their incubatory pouches. As to the growth the measurement curves show that the ♀♀ are larger everywhere (i. e. they grow quicker) than the ♂♂, and furthermore that the growth proceeds slower during the winter than during the war-

mer part of the year. Fig. 7 shows that the average size of the stock during the winter-season — from the middle of October till the middle of April — only increased with 2,64 mm, whereas in the course of the following 2 months — April 14th till June 4th — it increased with nearly the same, viz. 2,42 mm. It is difficult to calculate the growth of the young during the summer, as new young continually appear; but as it may be assumed that the earliest born young are to be sought among the largest individuals of the summer-stock, it appears from fig. 7 that the young born in late May have reached on June 25th or in the course of about a month, a length of 8 mm; as they were 2 mm in length when born they have thus during this time grown altogether 6 mm; on July 3rd the largest individuals were fully developed, and the ♀♀ matured at a length of 11 mm, the ♂♂ at 9 mm. The first-born young of the summer-stock reach thus maturity in the course of hardly $1^1/_2$ months.

There still remains, however, the questions regarding growth of the latest-born young, the number of generations, how many times each ♀ can breed, the duration of the period of incubation in the summer time, and finally whether the breeding individuals of the summer-stock after wintering can again breed the following spring. These questions can only be answered by the aquarium observations.

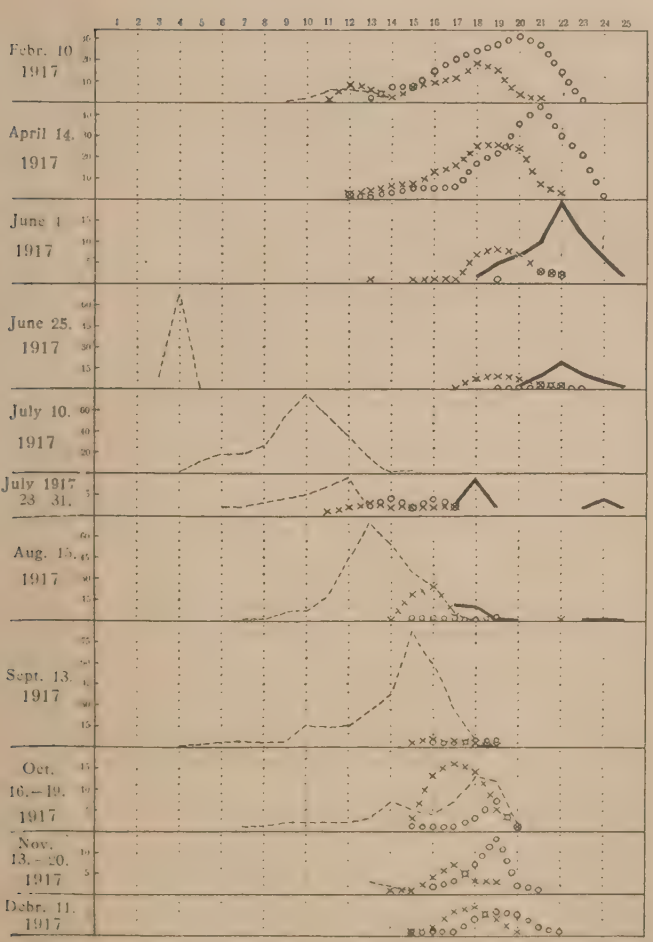
2. *Mysis flexuosa.*

The measurements of this species, which is our largest *Mysis*-species, will be found in table 4 at the end of this book. Fig. 8 comprises a graphical representation of the measurements from the Nyborg Fjord during 1917. It will be observed that the conditions in this instance are about the same as in the case of *Mysis inermis*. In February there is a stock of mysids not yet mature, and of which the greater part can be determined in reference to sex. In March (table 4) the average length of the stock has increased, and there was only one individual of the measured 164, which could not be determined as to sex. In April the sex of the entire stock was determined, but none of the mysids had yet got eggs or young in their incubatory pouches. This did not take place before the month of May; in 1918 the first breeding ♀♀ were observed about May 9th, and on May 15th (see table 4) the most of the ♀♀ had eggs or young in their incubatory pouches, the remainder (13 of 33 ♀) had small incubatory lamellæ, and were therefore not yet mature; on May 18th 1916 only 2 of 36 ♀ had not reached maturity. In the beginning of June 1917 no young had yet been hatched and none of the many ♀♀ carrying young had fully developed young in their incubatory pouches; not before June 25th of the same year do we find a group of newly born mysids, and in this group it was not possible with any certainty to distinguish between *flexuosa* and *neglecta;* it was, however, certain that both species were included. Vastly different in size from this group we find the wintered mysids, which are in full breeding activity; only a very few of the ♀♀ have not yet reached maturity.

That each ♀ of *Mysis flexuosa* as well as of *Mysis inermis* breeds several

times in succession was observed in the case of the many mysids, which carried young nearly ready for hatching in their incubatory pouches, and large and nearly ripe eggs in the ovaries; these eggs were of about the same size as the eggs in the incubatory pouch of the ♀♀ with newly laid eggs (abt. 1 mm in diameter in the ♀♀ of the winter-stock). With the *Mysis flexuosa*, which is often only slightly pigmented, the overial eggs are exceptionally easy to follow through their develop-

Fig. 8. Measurements of Mysis flexuosa.
Nyborg Fjord, 1917.
The ordinates are number of individuals, the abscissæ their lengths in mm.



Total number	♂ I G	♂ I %	♂ II G.	♂ II %	♀ with eggs or young I G.	♀ with eggs or young I %	♀ with eggs or young II G.	♀ with eggs or young II %	♀ without eggs or young I G	♀ without eggs or young I %	♀ without eggs or young II G	♀ without eggs or young II %	young G.	young %
280	16,63								18,70				11,82	
G. 17,83		29								63				8
327	17,91								20,08					
G. 19,20		41								59				
102.	18,90				21,77				21,00					
G. 20,85		30				64				6				
173.	19,37				22,38				21,13				3,90	
G. 13,57		17				33				5				45
314.													9,61	
G. 9,61														100
83.			14,14	17	24,00	10	17,72	15			15,00	17	10,21	41
G 14,22														
355.	22,00		15,63		23,80		17,69		22,00		17,10		13,32	
G 14,23		0,3		12,7		1,5		7,5		0,3		2,7		7,5
338.			16,63				18,67				17,75		14,07	
G 14,41				5				1				5		89
130			17,15								18,20		15,93	
G 16,62				40								12		48
53.			17,00								18,46		13,67	
G 17,40				36								53		11
12.			17,67	50							18,85	50		
G 18,21														

--- Young.
××× ♂
——— ♀ with eggs or young in the incubatory pouch.
ooo ♀ without „ „ „ „ „ „

G = Average size in mm.
% = Number of individuals in each group expressed in percentage of the entire stock.
I = Winter-stock.
II = Summer-stock.

ment, as owing to their refracting quality they are easily distinguished through the skin of the live animal. The ovaries of the ♀♀ carrying newly laid eggs in the incubatory pouch are only seen as indistinct stripes close below the back, but as the development of the eggs proceeds in the incubatory pouch, the eggs of the following brood become more and more distinct; when the eggs in the incubatory pouch have developed into young, the ovarial eggs in the meantime become so large that they form a large refractive mass in the fore part of the body, stretching from the lateral part of the masticatory stomach to the lateral edge of the thorax. The larger and more developed the young in the incubatory pouch are, the larger and more distinctly separated do the ovarial eggs appear. In ♀♀, the hatched young of which have just left the incubatory pouch, the ovarial eggs are so well developed, that they can be counted through the skin, and the number of eggs of the next brood can be predicted; the nucleus of the eggs are distinguishable as lighter spots.

On July 10th 1917 only young have been fished, there not happening to be any adults in the shoal, which was collected for investigation; that adult breeding individuals of the winter-stock are still to be found, will be seen from the other measurements in table 4 taken at about the same time of the year. The group of young has increased to an average size of no less than 5,7 mm since June 25th, and the largest individuals measure 15 mm; none of them are, however, mature yet, though several of the largest by means of the lens can be separated in ♂ and ♀. Already at about the end of July a large group of breeding ♀♀ is found, differing greatly in size from the breeding ♀♀ of the winter-stock. As in the case of *Mysis inermis* the only explanation of this is that they belong to the summer-stock, the largest individuals of which have grown into maturity; the breeding ♀♀ of the summer-stock average in length 17,92 mm, while the average length of the breeding ♀♀ of the winter-stock is 24,00 mm; the dying off of the breeding ♀♀ of the winter-stock and the fact that the ♀♀ of the summer-stock for the greater part have not hatched their first brood of young, are the natural causes of no newly hatched young being found in this sample.

In August the same two groups of mysids are found again, and of these the group of the winter-stock is about to disappear; the ♂♂, which have continually been inferior in number, are almost gone; in the sample from August 15th 1917 there is only 1 ♂ and 6 ♀ of the winter-stock left, while many of the summer-stock's ♀♀ without eggs in the incubatory pouch have now large eggs in the ovaries. In September all the individuals of the winter-stock have disappeared from the measurement lists, and there are only a few of the breeding ♀♀ of the summer-stock left. That many of these breed more than once in one breeding period was substantiated in the same manner as in the foregoing is described in reference to the winter-stock. Conforming with the smaller size of the breeding ♀♀ of the summer-stock, their eggs were also smaller than those of the winter-stock, viz. only $^3/_4$ mm in diameter. In October the breeding activity ceases; the stock grows and develops slowly throughout the winter, and in February it has reached the same stage, at which the winter-stock stood in February of the preceding year.

12 measurements, comprising altogether 1781 individuals collected from different other places than the Nyborg Fjord (the Limfjord, the Kattegat, the Isefjord, Kerteminde Bay and Svendborg Sound), show that *Mysis flexuosa* becomes larger in the

northern Kattegat and the Limfjord than in the Belts, but that the conditions otherwise are the same everywhere. In 1918 the first young appeared already in June by Hals, and in Svendborg Sound the largest young measured on June 23rd no less than 13 mm in length. From the Nyborg Fjord no measurements are published from June 1918, but from the journals I note that the first young were found in the *Zostera* during the first days of June, and that on June 18th the largest young measured 8 mm; in 1918 the young thus seem to have appeared somewhat earlier than in 1917.

The results of the measurement investigations of the *Mysis flexuosa* can briefly be put down as follows:

Mysis flexuosa is at the highest annual; the wintered stock dies off in the course of July and August every year. The breeding period lasts from the middle of May till some time in October, and lasts accordingly about a month shorther than the breeding period of *Mysis inermis*. The winter-stock breeds from the middle of May until it gradually dies off, the summer-stock from a little past the middle of July until some time in October. In 1918 the first hatched young appeared at about the beginning of June (the period of incubation lasted thus abt. 3 weeks), in 1917 they appeared a little later in the same month. The ♀ grows quicker and becomes larger than the ♂; the growth proceeds slowly during the winter and quickly during the summer. It will be observed from fig. 8 that the average size of the stock on October 16—19th was 16,62 mm, on April 14th 19,20 mm, which gives a growth of 2,58 mm in the course of 6 months, but from April 14th till June 25th, i. e. in the course of a little more than 2 months, the average size of the winter-stock increased from 19,20 mm to 21,33 mm, or about just as much. On July 10th, i. e. in the course of a little more than a month, the first-born young had reached a length of 15 mm; as the young measured 3,5 mm when born, they have grown 11,5 mm in this time. A little past the middle of July the first-born young have reached maturity, the ♀♀ at a size of 18 mm, the ♂♂ at a somewhat smaller size. The young reach thus maturity in the course of about $1^1/_2$ months. Similarly with the young of *Mysis inermis* many of the ♀♀ of the summer-stock as well as of the winter-stock breed more than once during the same breeding period.

There is, however, an essential difference between the curves of growth relating to the *Mysis inermis* and *Mysis flexuosa*. In the case of *Mysis inermis* a new and large group of young appeared in August and September as a result of the breeding activity of the summer-stock, while the average size of the stock was considerably reduced (see fig. 7). In the case of *Mysis flexuosa*, however, there is no sign whatever of a mass-production of young. There may be in both August and September a few single small young, but they do not differ from the older individuals as to form a separate group and are of no importance in relation to the many large and immature individuals of the summer-stock, which without doubt are the offspring of the winter-stock. The average size of the stock as a whole (see fig. 8) being unaffected by the appearance of young, increases from July till the month of June in the following year, when the new young appear. Comparing this with the fact that *Mysis flexuosa* breeds later than *Mysis inermis*, and that the young require longer time in reaching maturity, the conclusion is obvious that a considerably

larger part of the summer-stock of *Mysis inermis*, perhaps all the young born by the winter-stock, are able to breed before the winter, whereas this refers to only a smaller number of *Mysis flexuosa*, perhaps only the very first broods.

This question will be treated further in the report of the aquarium observation.

3. *Mysis neglecta.*

The measurements of this species are given in table 5; the measurements from the Nyborg Fjord during the year 1917 are given in graphical form in fig. 9 as an extract from table 5. As the conditions of this species remind very much of *Mysis flexuosa*, I shall not treat the curves and tables in detail, but directly state the results, which may be derived therefrom.

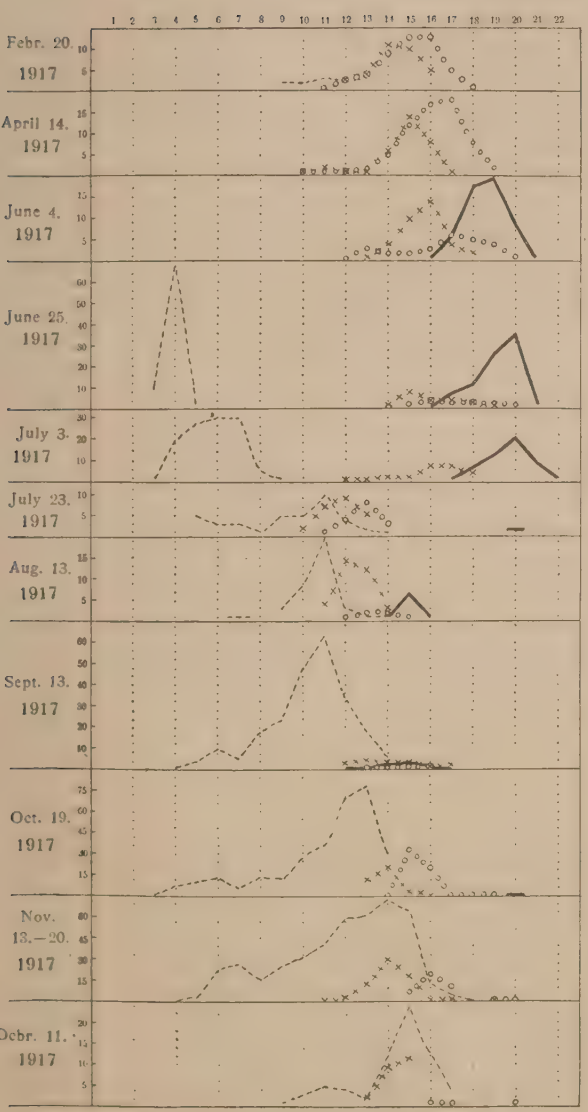
It will immediately be seen that *Mysis neglecta* like the other mysid species is annual; the winter-stock dies off during July and August, even though single individuals may be met with as late as October (fig. 9; see also table 5, Sept. 27th 1916). The winter-stock reaches maturity at the end of May and the beginning of June. On June 4th 1917 there were found among 55 ♀ with eggs, only 10 individuals with embryos (without pigmented eyes and thus only a few days old), the remaining having quite newly laid eggs. They continue to breed until they gradually all die off in the course of July and August; the young appear about the end of June; the newly hatched young measure about 3 mm, but already on July 3rd the largest of this group measure 9 mm in length, and in the last days of July the largest have reached maturity at a size of 16 mm (♀) and 15 mm (♂). The ♀♀ of the winter-stock as well as of the summer-stock breed several times, as might be seen by the well-developed ovarial eggs in the animals carrying eggs. The period of breeding ceases at the end of October. In the Limfjord this species is a little larger than in Nyborg Fjord; in 1918 newly hatched young were found in the Limfjord already at the end of May and in the beginning of June.

According to the above, *Mysis neglecta* breeds much later in the year than *Mysis flexuosa*, and similarly with this species all the young born by the winter-stock do not seem to reach maturity the same year in which they are born. Owing to the appearance of the newly hatched young, there is certainly (see fig. 9) a slight decline in the average size of the entire stock from August till September, but there does not appear, as the case was with the *Mysis inermis*, a new large group of young in the autumn as a result of the breeding activity of the summer-stock. This matter will, however, be treated later on.

Fig. 9. Measurements of Mysis neglecta.

Nyborg Fjord, 1917.

The ordinates are number of individuals, the abscissæ their lengths in mm.



Total number	♂ I G.	♂ I %	♂ II G	♂ II %	♀ with eggs or young I G	♀ with eggs or young I %	♀ with eggs or young II G	♀ with eggs or young II %	♀ without eggs or young I G.	♀ without eggs or young I %	♀ without eggs or young II G	♀ without eggs or young II %	young G.	young %
91. G 14,28	14,33	35							14,92	55			10,56	10
101. G. 15,50	14,59	34							15,96	66				
117. G. 17,22	15,61	30			18,60	47			16,48	23				
203 G 12,89	16,05	11			19,10	42			17,22	9			3,90	38
192. G 11,07	16,08	12			19,69	29							5,81	59
80. G 11,00			11,74	29	20,00	2,5					12,81	20	9,38	48,5
85 G 12,04			12,42	39			15,00	11			13,50	7	10,73	43
258 G 10,78			13,85	5			14,92	5			14,50	2	10,30	88
422. G. 12,68			13,80	8,3	20,00	0,2					15,62	14	11,21	77,5
550. G 12,62			14,14	12							16,26	7	11,53	81
93 G 14,43			14,41	24							17,67	3	14,29	73

--- Young.

××× ♂

▬▬ ♀ with eggs or young in the incubatory pouch.

ooo ♀ without „ „ „ „ „ „

G = Average size in mm.

% = Number of individuals in each group, expressed in percentage of the entire stock.

I = Winter-stock.

II = Summer-stock.

Aquarium Observations.

The majority of these observations are made in the glass aquaria described earlier, and in which there was water from the Nyborg Fjord containing some fine algæ; the mysids were fed with fresh *Mytilus*, which were removed from their shells and cut into small pieces. To begin with the newly hatched young seemed only to live on Detritus, which always gathered at the bottom of the aquaria; but when they reached a size of 6—7 mm they eagerly partook of the meat-food. This they generally devoured by seizing a little piece of the meat with their mouthparts and front pair of peræopods, and with a strong backward spring removed it from any piece attached to it; floating in a vertical position in the water and still holding the meat with the front pair peræopods, they could devour the meat in peace.

The supervision of the aquaria was carried out in the following manner: The mysids were first fished out and then placed in a small jar, from which they were taken up and placed one by one on a watch-glass containing a little water and placed under a binocular microscope; the degree of development of the ovaries and the eggs or young in the incubatory pouch could thereby easily be examined, as the thin and most often only slightly pigmented thorax and incubatory lamellæ of the mysids are very transparent. In opposition to *Gammarus locusta* the mysids are difficult to keep alive in the aquaria, and it is still more difficult to make them breed there. Though in each experiment several fully developed ♂♂ were placed in the aquaria for each adult ♀, many unsuccessful attempts had to be made, before I succeeded in getting a single ♀ to breed, as the following will show.

As mentioned in the chapter on measurement investigations, it is also possible with reference to the mysids to distinguish between a winter-stock, which breeds in the spring and then dies off during the summer, and a summer-stock, comprising all the young born in the course of the spring and summer. For this reason a distinction is continually made in the following between these two categories, whereby the material is easier to survey.

1. *Mysis inermis*.

In the table given below the results of the aquarium observations of *Mysis inermis* are gathered. They comprise several experiments, partly with ♀♀ of the winter-stock and partly with ♀♀ of the summer-stock. Where the experiment includes only a single individual, the columns „eggs“, „young without eyes“, „young with eyes“ and „empty“ are supplied with dates, referring to when the individual in question was found with eggs, young without distinctly pigmented eyes, young with distinctly pigmented eyes in the incubatory pouch, or with empty incubatory pouch respectively. Where the experiments comprise several individuals, the dates are arranged to the left, and the number of ♀♀, which on the day in question had eggs, young without eyes etc. in the incubatory pouch, is placed in the respective column opposite to the date stated. It must, however, be particularly mentioned that the dates given are not always expressions of the rate of development of the eggs or the young in the incubatory pouch. Such is only the case with the experi-

Mysis inermis.

Winter-stock.

	Eggs	Young without eyes	Young with eyes	Empty
Exp. I 1918	2/5	10/5	—	—
Exp. II 1918	—	—	—	2/5
	4/5	—	—	14/5
Exp. III 1919	—	—	31/5	6/6
	6/6	—	—	—
Exp. IV 1919	—	—	21/6	23/6
	23/6	—	—	—
Exp. V 1918	2/5	11/5	21/5	28/5
	24/6	—	—	1/7
Exp. VI 1917	6/6	1	—	2	—
	11/6	1	1	1	—
	13/6	1	1	1	—
	15/6	2	—	1	—
	17/6	1	1	—	—
Exp. VII 1917	7/6	1	—	—	1
	13/6	2	—	—	—
	16/6	2	—	—	—
	20/6	1	1	—	—
	23/6	—	—	—	2
Exp. VIII 1917	21/6	—	—	4	—
	26/6	—	—	1	2
	28/6	3	—	—	—
	30/6	3	—	—	—
	10/7	—	—	1	1
	17/7	1	—	—	1
	25/7	1	—	—	—
Exp. IX 1917	22/6-25/6	7	—	—	—
	27/6	—	6	—	—
	3/7	—	—	5	—
	9/7	4	—	—	1
	16/7	—	—	—	2
	21/7	—	—	—	1
Exp. X 1917	22/6	—	—	15	—
	25/6	7	—	6	—
	27/6	9	—	—	—
	3/7	—	5	1	—
	9/7	1	—	3	—
	16/7	—	2	—	—
	21/7	—	—	1	1
	4/8	—	—	—	2

Summer-stock.

	Eggs	Young without eyes	Young with eyes	Empty
Exp. XI 1919	2/7	7/7	12/7	18/7
	18/7	23/7	30/7	5/8
	25/8	—	—	2/9
	15/9	21/9	29/9	8/10
	11/10	17/10	25/10	31/10
Exp. XII 1918	10/7	—	—	?
	21/7	—	—	5/8
	16/8	—	—	30/8
Exp. XIII 1918	—	—	23/9	12/10
Exp. XIV 1917	28/7	10	10	—	—
	4/8	5	—	12	—
	11/8	4	2	2	8
	21/8	2	—	4	—
	2/9	—	—	3	2
Exp. XV 1917	2/9	1	2	2	?
	12/9	3	—	1	6
	22/9	1	4	—	4
	28/9	1	2	—	5
Exp. XVI 1918	17/6	—	—	—	5
	1/7	—	—	—	4
	23/7	1	—	—	1
	31/7	1	—	—	—
Exp. XVII 1917	2/7	—	—	—	4
	10/7	3	1	—	—
	17/7	2	1	—	1
	25/7	1	—	—	3
	4/8	1	—	—	1
	11/8	1	—	—	1
	20/8	1	—	—	1
	1/9	—	1	—	1
	10/9	—	—	1	—
	22/9	—	—	—	1

ments made in 1919; they were made in small glass jars, which could be carried about and attended to daily on board the Station's steamer. All the other experiments were made in aquaria ashore, which could not be attended to every day; owing to this the tables of these experiments most often only give information of the conditions on such and such a day, compared with the last supervision of the aquaria. The cause of the number of individuals in many of the experiments being reduced so quickly is due to the above mentioned high rate of mortality in the aquaria.*)

The Results of the Aquarium Observations on *Mysis inermis*.

It is obvious that great care must be taken when transmitting conclusions drawn from the aquarium observations to the conditions of the free nature; but the numerous conformities between the aquarium observations and the measurement investigations, tend to prove the probability that the general results of the aquarium observations may refer to the actual conditions of the free nature too. This is therefore taken into consideration in the following.

As mentioned in the chapter of the measurement investigations the questions to be solved by the aquarium observations were: the duration of the period of incubation, how often each ♀ could breed, the growth of the young, the number of generations and finally whether or not the breeding mysids of the summer-stock can live throughout the winter and resume breeding the following spring. As to the first question, the measurement investigations showed that the hatching of the broods born earliest in the year lasted about one month. The aquarium observations conform hereto; thus Experiment V shows that a brood of young, produced from eggs laid about May 2nd, did not leave its mother's incubatory pouch before about May 28th. According to experiments I and V the development from egg to young without pigmented eyes lasted at this time of the year about 8 to 9 days**) and another 10 days elapsed before the young obtained pigmented eyes; furthermore a week passed by before they left their mother's incubatory pouch. Later on in the summer the development proceeds much quicker. Experiment VI shows thus

*) A detailed account of how the aquarium observations proceeded will be found in the Danish edition of this book (p. 82–87).

**) It must be remembered that when a mysid is caught in the free nature with e. g. eggs in its incubatory pouch, and thereupon placed in an aquarium, one does not know to a certainty of one or two days, how long ago the eggs have been laid, as usually it is impossible through the incubatory lamellæ to substantiate the stage of cleavage in which the eggs are. It being of importance to get as viable mysids as possible in the aquaria, the only thing to be done without injuring the animal, is to convince oneself by means of a binocular microscope as to whether the incubatory pouch contains 1) eggs, 2) young without pigmented eyes, 3) young with pigmented eyes or 4) is empty. Whether the eggs are at the beginning or at the end of any of these stages it is most often impossible to judge from such a quick investigation; this can only be determined by observing the development in the aquaria. In cases where it is expressively stated that a mysid has newly laid eggs this statement is based upon the eggs being tranparent and spherical, which experience has proved always to be the case with newly laid eggs.

that in early June only 5 days elapsed between each of the 3 development stages, which results in a period of incubation of about 17 days; and according to experiment VIII a ♀, which carried eggs for at least the second time on June 28th, got eggs again just before July 17th, given a period of incubation of 19 days. Experiment IX shows a period of 6 days between each stage of development and a period of incubation of 17 days, viz. from June 22nd to July 9th; finally experiment X gives in the case of one individual a period of incubation of only 14 days, viz. from June 25th till July 9th. Reverting to the summer-stock, experiment XI gives the exact dates of the time of development from egg to young from the beginning of July till late October. The first brood was hatched in the course of 16 days, 2nd brood in 18 days; from 3rd brood no young were produced, but 4th brood of eggs was laid 21 days after 3rd brood and the hatching of 4th brood lasted no less than 23 days, and the hatching of 5th brood 20 days. In accordance herewith 5, 5 and 6 days respectively elapsed between each stage of development of the eggs and young in the first half of July, 5, 7 and 5 days in the last half of July and the first half of August, but 6, 8 and 9 days in the end of September and 6, 8 and 6 days in October. Experiment XIII shows that during September—October even 2 weeks can elapse before the young, which have already pigmented eyes, are ready to leave the mother's incubatory pouch.

With *Mysis inermis* the duration of the period of incubation is thus dependent upon the season, as in the warm summertime the young are hatched in the course of a little more than 2 weeks, but in the spring and autumn not before 3—4 weeks have elapsed after the eggs are laid.

In reference to how often each ♀ can breed, the aquarium observations of the winter-stock show several instances, where one or more mysids have bred twice, wiz. experiments II, III, IV, V, VI, VII and IX. In two other experiments, VIII and X, some of the mysids were seen to bred three times in succession. According to experiment XV some mysids of the summer-stock breed twice and others (experiments XII, XIV and XVII) three times, but experiment XI shows an instance where one ♀ produced no less than five broods. In accordance with the fact that in the free nature mysids with empty incubatory pouch are very seldom met with, the aquarium experiments show that the mysids most often got a new brood of eggs in the incubatory pouch immediately after the young of the preceding brood had left it. Only in experiments V and XI a longer time elapsed between the hatching of the young and the subsequent oviposition, viz. 26 and 20 days respectively, or about the same time, which at that time of the year is required to ripen a new brood of eggs in the ovaries. For this reason it may be concluded that the brood of eggs, which normally should have been laid immediately after the hatching of the young, has for some reason or other died, and a whole period of incubation had to elapse before a new brood of eggs could ripen in the ovaries. Looking at the matter in this light, there should be nothing to prevent a ♀ of the summer-stock in breeding 6 times in succession, as e. g. the ♀ in experiment XI got eggs five times and that a whole period of incubation passed between the 2nd and 3rd laying of eggs. Unfortunately I had no success in substantiating this number of ovipositions with any of the mysids, though several trials were made, and for this reason I consider in the following 3 successive ovipositions as regards

the winter-stock and 5 successive ovipositions as regards the summer-stock, as being maximum. Within these limits it holds good to as well the summer-stock as the winter-stock that the earlier in the year the mysids reach maturity, the greater is the number of broods they are able to hatch. According to the measurement investigations a number of the ♀♀ of the winter-stock cannot normally breed more than twice, because several of the ♀♀ of this stock have not yet reached maturity in late June; as the winter-stock by the end of July has practically died off, the most of these individuals can at the highest produce 2 broods of young before they die.

Regarding the growth of the young, the aquarium observations supply various information, which is indicated by the curves of growth given below (fig. 10). The occuring uneveness of some of these curves is due to the fact that the increase in length of the mysids, as will be known, only takes place at the time of moulting, and the growth should therefore really be represented by several horizontal curves connected with vertical curves, whereby each curve of growth would form a step-formed ascending curve. As, however, the separate measurements of the mysids were carried out at irregular intervals and without reference to the moultings, these measurements are just set off on fig. 10, and the points obtained thereby are connected with straight lines. The curves obtained by this proceeding do therefore not give a quite exact picture of the growth, but the deviations are not great, especially where the measurements are taken at short intervals of time. It must also be taken into consideration that the measurements, related as they are to live animals, which might not be injured, cannot claim absolute exactness; they are, however, quite serviceable for mutual comparisons. The curves of growth of the mysids, which reached maturity in the aquaria, are continued with thick lines from the time the animals commenced breeding.

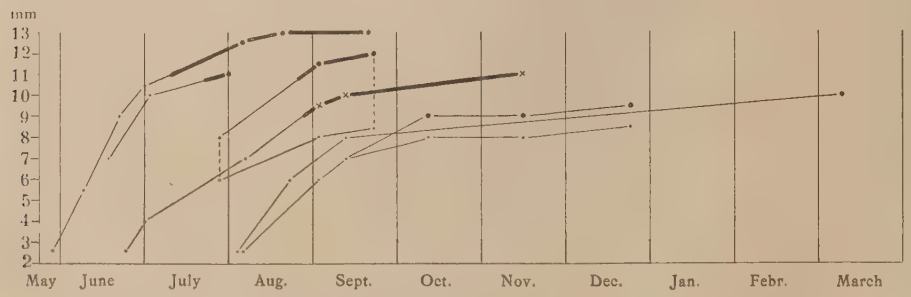


Fig. 10. Growth of *Mysis inermis* in aquaria.

Young.
♂, mature.
♀, not mature.
♀, mature.

The curve farthest to the left indicates the growth of a mysid, hatched in aquarium on May 28th 1918. It proved to be a ♀, which reached maturity, at a length of about 11 mm, on July 10th or hardly $1^1/_2$ month after being hatched. It bred three times and died in September of the same year at a length of 13 mm (mentioned in experiment XII). The curves of the 4 ♀ mentioned in experiment XVII (not included in the figure) coincide with those of the mysid just mentioned, as upon being placed in the aquarium on July 2nd they measured 10—11 mm and on August 4th of the

same year 12 mm; they must be considered as having been born about simultaneously with this mysid, and they commenced breeding at about the same time viz. about July 10th. The results obtained by the measurement investigations are thus confirmed, as these results state that the individuals born in the earliest part of the year (late May) reach maturity in the course of about $1^1/_2$ months. The growth of the mysids conform too very well with the measurements (see page 66); only during the months of July and August the growth of the ♀♀ of the summer-stock in the free nature at the same time of the year proceeded somewhat quicker. — The curve immediately below the former and which commences on June 17th indicates the growth of the largest of the mysids mentioned in experiment XVI; it will be noted that this mysid, which, according to the curve of growth, must have been born a little later than those mentioned above, also reached maturity a little later than these, viz. on July 22nd. — Another curve of growth commences on June 23rd, at which time a brood of young was born in the aquarium (experiment IV). On July 1st there were altogether 9 young from this brood, all measuring 4 mm in lentgh, but in the course of July and August the 6 died, and on September 12th another one, measuring $8^1/_2$ mm, died; there remained thus only 2, both of which were ♂. These 2 ♂ lived until November 15th of the same year, when they had reached a length of 11 mm. As the curves show, this brood grew slower than the brood of May 28th, and not before the end of August, i. e. two months after the hatching, did the largest of the mysids reach maturity. — Conforming herewith a number of young, placed in an aquarium on July 27th at a length of 6—8 mm, the curves of growth of which will be seen in fig. 10, being connected by means of dotted lines, reached maturity on August 25th. It must be assumed that they were hatched at about the same time as the earlier mensioned mysids. — The last two curves show the growth of mysids born in aquarium on August 3rd and 5th respectively; none of these mysids reached maturity. The curve which commences on August 5th indicates the growth of a brood of young numbering 6 individuals, all born on the date stated (experiment XI). On October 11th the largest of these young measured 9 mm; though they were still undeveloped, they could be determined as ♀; the smallest one measured 8 mm and could not be determined as to sex. On November 15th the conditions were the same, but before December 23rd the two last individuals had died off; the one of these was an undeveloped ♀ measuring $9^1/_2$ mm, the other a young measuring $8^1/_2$ mm. The other curve indicates the growth of a ♀ born in the aquarium on August 3rd 1917 (experiment XIV); it lived through the winter in the aquarium and died in the beginning of March 1918 at a length of 10 mm, but had as yet only quite small incubatory lamellæ; it will be noted that the growth was much slower during the winter than during the summer.

Thus fig. 10 shows that the growth proceeds quicker with the young born early in the year than with those born at a later date, and furthermore that the latter reach maturity quicker than the first named.

We have now certain holds from which to judge the question regarding the number of generations that *Mysis inermis* produces annually. Designating the young born by the winter-stock as Generation I, it can be proved that most of the mysids of this generation reach maturity before the summer is over. We saw that each ♀ of the winter-stock breeds at the most 3 times, and as the breeding period commences already at the end of April, all the 3 broods of one of the early breeding mysids could be hatched before the end of June; in the above we saw furthermore that mysids, which were born on June 23rd, reached maturity before the winter. However, several females of the winter-stock continue breeding some time in August, and of course the latest born young of these do not reach maturity before the winter; but as the main portion of the winter-stock has already died off in the beginning of July, it will be understood that by far the greatest number of Generation I are able to produce young before the winter. The earliest born young of Generation I appear about the end of May and reach maturity in the beginning of July of the same year; their first brood of young (Generation II) appears a little

past the middle of July (experiment XI). Unfortunately it has been impossible, notwithstanding several attempts, to keep a brood of young, born at this time, in the aquaria; but as it has been proved that the young, which were born as early as June 23rd, did not reach maturity before the end of August, and that furthermore the time till maturity was reached as well as the duration of the period of incubation lasted the longer as the autumn approached, it can safely be assumed that only a very few, viz. the earliest born mysids of Generation II, will be enabled to produce new young (Generation III), before the breeding period ceases about the end of October. In accordance hereto it was observed that the earliest born individuals of Generation II did not reach maturity before the winter.

Thus no more than 3 generations can come into consideration, and the question now arises as to whether the breeding individuals of the summer-stock may live throughout the winter and resume breeding the following spring. In the aquarium observations mentioned hitherto, I have not succeeded in maintaining any of the breeding mysids of the summer-stock alive throughout the winter; the most of them died before, and the remainder a short time after the breeding period had ceased. Only in the aquarium observations mentioned page 94, comprising a stock of mysids of the summer-stock, did I succeed in proving that some *Mysis flexuosa* (and probably also at least one *Mysis neglecta*), after breeding at the end of the breeding period in 1917, lived through the winter and commenced breeding again in the following spring. It must therefore be assumed that also *Mysis inermis*, the biological conditions of which are so closely related to the other two species, is able to do so too. The greater part of the individuals, which breed earliest in the spring (the largest), are without doubt such wintered mysids that already once before have been breeding, viz. at the end of the preceding breeding period, whereas the individuals of the winter-stock, which breed later in the year, are the mysids born at the end of the preceding breeding period, and which therefore did not reach maturity before the winter. Only a very small percentage of the mysids have the opportunity to breed in two breeding periods, this being evident from the fact that only a very few of the ♂♂ are found during the winter months with fully developed pleopods of the 4th pair; for it is not probable that a ♂, which once had well developed pleopods, should loose these again, and in the aquaria such cases have never been observed.

I have never succeeded in observing the mating process of the mysids,*) though I have often kept mature mysids under observation for hours; probably it lasts only a very short time, and furthermore I believe it takes place during the night. When many mature ♂♂ were kept together in an aquarium, it could be observed in the morning that with some of them the spermatozoa were seen hanging like a fine thread from each of the two processes into which the *vasa deferentia* terminate. The elongated pleopods of 4th pair so characteristic for the mature ♂♂ are generally assumed to be mating organs; but about this we, too, still know nothing. As with *Gammarus locusta* the ♀♀ moulted with every new oviposition,

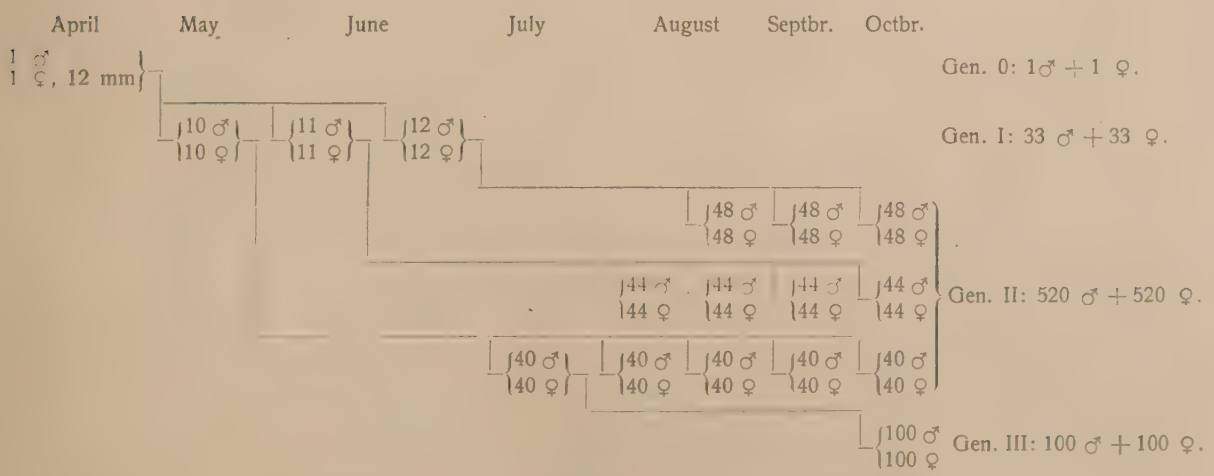
*) Van Beneden (3, p. 23) says: *„Les mysis s'accouplent et la fécondation des oeufs a lieu dans l'intérieur du corps de la femelle"*, but unfortunately he gives no further informations about this most interesting subject.

i. e. with a shorter or a longer period between each moult according to the season In conformity with the growth being quicker with the young mysids than with the older ones, the moulting takes place more often with the young than with the adults, but the cast cuticles are often consumed immediately after the moult, making it very difficult to control. The cast cuticles were usually split along the posterior and lateral edges of the thorax; through the opening thus formed the mysid has evidently released itself from its old skin.

The number of young each ♀ produces is dependent partly upon the size of the mother-animal (Apstein (2)) and partly upon the season; thus the results of a number of countings on eggs and young from the incubatory pouch of *Mysis inermis* collected in Nyborg Fjord were as follows:

The length of the mother-animal:	9 mm	10 mm	11 mm	12 mm	13 mm	14 mm	15 mm
4/6 1917				$20_{,5}$ (6)	$22_{,3}$ (6)	$23_{,2}$ (6)	
25/6 "					$22_{,8}$ (6)	$23_{,7}$ (6)	28 (1)
13/8 "	$7_{,8}$ (6)	$8_{,1}$ (6)	$9_{,7}$ (6)	$11_{,2}$ (4)	14 (2)		
30/8 "	$5_{,5}$ (6)	$7_{,8}$ (6)	$9_{,2}$ (6)		12 (1)		
16/10 "		$5_{,2}$ (5)	$5_{,6}$ (5)		10 (1)		

The figures of this table show the average number of eggs or young found in the incubatory pouches; the figures in brackets state the number of individuals examined. It will be observed that the number of eggs and young within the same date increases with the length of the mother-animal, but within the same length decreases more and more from June till October. To form an idea of the



Generation I—III total: 653 ♂ + 653 ♀ = 1306 individuals.

production, which one pair of *Mysis inermis* in the most favourable case can produce in the course of a breeding period, a similar scheme as with *Gammarus locusta* can be made, the hypothetical character of which must again be emphasized.

In the above scheme Generation 0 indicates one pair of early breeding mysids of the winter-stock; they get 3 broods of young from the end of May till the end of June; assuming that the ♀ to begin with measures 12 mm, the first brood amounts to 20 young (see the table p. 79). According to the measurement investigations the mother-animal may in the beginning of June be assumed to have grown to 13 mm, for which reason the second brood, which is born in the middle of June, amounts to 22 young, and the third brood born in the end of June, when the mother-animal measured 14 mm, amounts to 24 young. Generation I consists thus of three broods of young or 66 mysids altogether. Assuming the half of the hatched mysids to be ♂♂ and the other half to be ♀♀, the 10 ♀ of the first brood of Generation I will in the course of July – October each get 5 broods of young; if in using the table p. 79 we reckon that on an average 8 young are born in each of these broods, the production of the first brood of Generation I will amount to 5×80 mysids. The 11 ♀ of the second brood of Generation I, born a period of incubation later that the first brood, will at the most not get more than 4 broods of young, each brood of 8 individuals, or 4×88 mysids altogether, before the breeding period is over. The 12 ♀ of the third brood of Generation I get in the same manner only 3 broods of young, each comprising 8 individuals, or 3×96 mysids altogether. Generation II totals thus 1040 mysids, but of these only the broods born in July and which comprise 40 ♀, can be assumed to reach maturity and be able to breed before the breeding period ceases. Assuming that these measure 9 – 10 mm in length when maturity is reached, they will each get 5 young about the end of October, whereby Generation III will comprise altogether 200 mysids.

The production of a pair of *Mysis inermis* will in the course of one breeding period at the highest comprise 66+1040+200=1306 individuals, even if they all live until the end of the breeding period. In reference to the ♀♀, which though belonging to the winter-stock do not reach maturity before late June (see page 76) and therefore only get 2 broods of young each before dying off, it can in the same manner be reckoned that they at the highest produce 442 individuals (2 generations) before the breeding period ceases.

2. *Mysis flexuosa.*

A general view of the aquarium observations is included in the table given below. The remarks stated page 72 relating to the table of observations on *Mysis inermis*, refer to this table as well. A further account of these observations will be found in the Danish edition of this book, pages 93 – 97.

Mysis flexuosa.

Winter-stock.

		Eggs	Young without eyes	Young with eyes	Empty
Exp. I 1918		$^{9}/_{5}$	—	$^{21}/_{5}$	—
		$^{9}/_{6}$	—	—	$^{1}/_{7}$
		$^{10}/_{7}$	—	—	—
Exp. II 1918		—	—	—	
		$^{19}/_{5}$	$^{27}/_{5}$	$^{5}/_{6}$	$^{12}/_{6}$
Exp. III 1919		—	$^{31}/_{5}$	$^{4}/_{6}$	$^{10}/_{6}$
		$^{11}/_{6}$	$^{16}/_{6}$	$^{26}/_{6}$	$^{3}/_{7}$
		$^{3}/_{7}$	$^{8}/_{7}$	$^{18}/_{7}$	
Exp. IV 1919		—	—	$^{31}/_{5}$	$^{9}/_{6}$
		$^{11}/_{6}$	—	—	—
Exp. V 1917		2	—	—	—
		—	2	—	—
		—	1	1	—
		—	—	2	—
		—	—	1	—
		—	—	—	1
Exp. VI 1917		2	—	—	—
		1	1	—	—
		—	2	—	—
		—	1	1	—
		1	—	—	1
		—	1	—	—
Exp. VII 1917		—	4	—	—
		—	2	2	—
		—	—	3	1
		3	—	—	—
		—	2	—	—
		—	—	2	—
		1	—	—	—
Exp. VIII 1917		4	—	—	—
		—	4	—	—
		—	—	4	—
		3	—	—	—
		—	2	—	—
		—	—	2	—
		1	—	1	—

Summer-stock.

		Eggs	Young without eyes	Young with eyes	Empty
Exp. IX 1919		—	—	—	
		$^{14}/_{7}$	—	—	
Exp. X 1919		—	$^{18}/_{8}$	$^{24}/_{8}$	
Exp. XI 1917	$^{11}/_{8}$	2	3	5	
	$^{15}/_{8}$	1	5	4	—
	$^{20}/_{8}$	4	5	—	1
	$^{1}/_{9}$	—	7	—	3
	$^{10}/_{9}$	—	—	5	4
	$^{15}/_{9}$	—	—	1	8
	$^{18}/_{9}$	—	—	—	9
					8
	$^{28}/_{9}$	—	—	—	7
				—	2

The Results of the Aquarium Observations on *Mysis flexuosa*.

The questions which the aquarium observations on *Mysis flexuosa* should treat are essentially the same as set forth in the results of the observations on *Mysis inermis*.

The duration of the period of incubation was also here dependent upon the season. The measurement investigations showed that the first young appear in the beginning of June, and that the hatching of these lasted about 3 weeks. Experiment I shows, in accordance herewith, that a brood of eggs laid on May 9th, developed into young with pigmented eyes in the course of 12 days, and experiment IV that in the course of 10 days such young were able to leave the incubatory pouch; the period of incubation lasted thus altogether 22 days; Experiment II shows that another brood of eggs laid on May 19th was hatched to free-living young in the course of 24 days. The best information regarding the duration of the period of incubation is gained from experiment III, which shows the stages of eggs and young in a ♀, caught on May 31st in the free nature, and which in its incubatory pouch carried young with pigmented eyes. Already on June 4th these young had fully pigmented eyes and left the mother-animal's incubatory pouch on June 10th. Comparing these two last dates with the corresponding dates in experiment II, it will be noted that the ♀ in experiment III must have got its first brood of eggs about May 17—18th, which gives a period of incubation lasting 23—24 days; the next brood of eggs had a period of incubation lasting 22 days, and the third brood 20 days. It will also be observed that the development from egg to young without pigmented eyes lasted 5 days, from young without pigmented eyes to young with pigmented eyes 10 days, and from young with pigmented eyes to free-living young 5—7 days. Experiment V gives seemingly a period of incubation of only 16 days, viz. from June 7th till June 23rd, but the eggs have evidently not been newly laid when the mysid was placed in the aquarium; the same refers to experiments VI and VIII, where the periods of incubation, according to the table, are only 19 and 18 days respectively at the most; in this instance a couple of days must be added in order to obtain the correct period of incubation. In experiments VII and VIII on the other hand the hatching of the second brood of eggs was delayed noticeably, the period of incubation lasting at least 26 days, viz. from July 9th till August 4th; it is especially the development from young with pigmented eyes to the free-living young which has lasted unusually long, viz. 14 days; in experiment III, 3rd brood, this development only lasted 5 days. Experiment XI shows that in August and September the hatching of young also lasted a considerable time. The ♀♀ No. 1 and No. 2 (see Danish edition page 96), which on August 11th carried eggs, had thus 21 days later, on September 1st, only young without pigmented eyes in their incubatory pouches; even when reckoning that on the following day, September 2nd, the young had reached the next stage, i. e. had become young with pigmented eyes, at least 5 days must elapse, according to the foregoing, before they can leave the mother's incubatory pouch, and this gives a period of incubation of altogether 27 days; ♀ No. 6, which carried newly laid eggs on August 15th, hatched young of this brood in the days between September 10th and 15th, the period of incubation being at the least 27 days and the most 31 days; nor had

♀♀ Nos. 7—9, which got eggs between August 15th and 20th, hatched this brood of eggs before the days between September 10th and 15th, which gives a period of incubation of at the least 22 days, at the most 31 days. Finally ♀ No. 10 was empty on August 20th, but had ripe eggs in its ovary; it has probably 1 or 2 days later got eggs in its incubatory pouch, which corresponds very well with the fact that on September 1st it had young without pigmented eyes, and on the 10th of the same month young with pigmented eyes. On September 18th it had hatched all its young, and when putting August 22nd down as the date for the oviposition, a period of incubation lasting 27 days is obtained. Even though these figures are only approximate, they show nevertheless that the duration of the period of incubation, which in May and June was a little above three weeks, and in July decreased to 20 days, increased in August and September to about 4 weeks.

Experiments I and III of the aquarium observations show that those ♀♀ of the winter-stock, which commence breeding in May or June, can hatch three brods of eggs before they, at the latest in the course of August, die off. According to the measurement lists there are a good deal, which do not breed so often; thus the lists (table 4) show that on July 5th 1916 there were still some ♀♀ of the winter-stock, that had not yet reached maturity; these would thus at the most be able to produce 2 broods of young before they expired at about the end of August. But as by far the greatest number of mysids of the winter-stock reach maturity in the course of June, it must be assumed that the most of the ♀♀ of the winter-stock normally get 3 broods of young before they die off. On the other hand experiment III showed, that a ♀ of the winter-stock which still lived 25 days having had its 3rd brood, was not able to breed any more; 3 broods of young can therefore normally be assumed as maximum for the winter-stock. As regards the summer-stock the measurement investigations show that the earliest born individuals reach maturity a little past the middle of July; unfortunately I have not been able to keep any such individuals alive in the aquaria long enough to ascertain how many days the hatching of first brood lasted; according to the foregoing, however, it can not be far wrong to set the period of incubation at about 26 days, after which the eggs of the 2nd brood are laid at the earliest in the days immediately following August 11th. But experiment XI shows, that of 10 ♀ of the summer-stock the 5 individuals, which on August 11th had eggs or young without pigmented eyes, produced only one brood, whereupon the want of ripe eggs in the ovaries, and the fallen-in incubatory lamellæ distinctly showed that they were not going to breed any more in that breeding period. The other 5 individuals, which on August 11th had young nearly ready to be hatched, got new eggs in the days between August 11th and 20th, but with that their breeding activity ceased. One seems entitled to conclude that the ♀♀ of the summer-stock breed at the most twice in one breeding period.

The growth of the young in the aquaria is explained in the form of curves in fig. 11. The general remarks pertaining to fig. 10 serve also for these curves. In opposition to *Mysis inermis* none of *Mysis flexuosa* born in the aquaria reached maturity. Not before the larger aquarium experiment mentioned

page 95 did I succeed in obtaining any *Mysis flexuosa*, born in aquarium, that reached maturity in the same year.

From a brood of young hatched on June 10th 1919 (experiment III) 2 ♂ lived until January 4th 1920; they grew about equally fast; their curve of growth is shown to the left in fig. 11. In the first days of August their sex was easily distinguishable, the 4th pair of pleopods beginning to become elongated; they were, however, not fully developed before the breeding period ceased, and both of them died before reaching full maturity at a length of 18 mm. The next curve of growth shows the growth of some mysids hatched in aquarium on June 19th 1917 (experiment V). The all grew about equally fast until August, when the difference in size between the ♂♂ and ♀♀ became evident; the 2 branches of the curve of growth show the growth of the smallest ♂♂ and the largest ♀♀; all these mysids died in the course

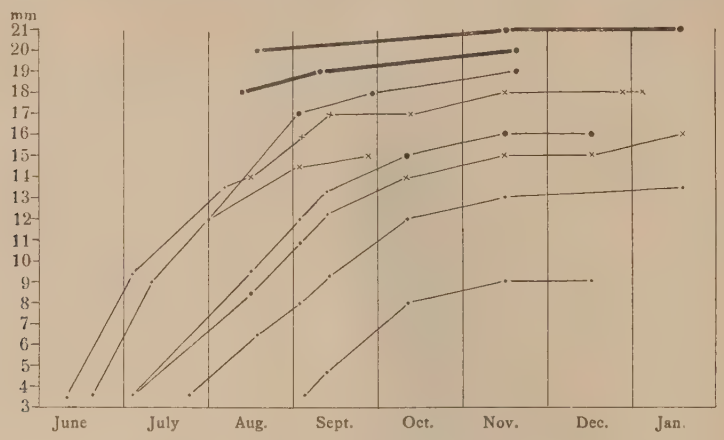


Fig. 11. Growth of *Mysis flexuosa* in aquaria.

·—·—·. Young.
×—×—× ♂, not mature.
•—•—• ♀, not mature.
•—•—• ♀, mature.

of the autumn before reaching maturity; before this the largest ♂♂ had nearly fully developed pleopods of the 4th pair, but the ♀♀ had only very small incubatory lamellæ. The bifurcated curve of growth, which commences at July 3rd, shows the growth of a brood of mysids numbering 8 individuals born in the aquarium on the date stated (experiment III); the one branch represents the smallest, the other the largest individuals. In October the sexes were easily distinguishable, but though they were still 5 individuals alive on November 15th, they all died before February of the following year; the ♂♂, which were the last to die, were not yet fully developed. Fig. 11 includes also the curve of growth for the brood of young from experiment III, which was born on July 23rd 1919. Originally this brood comprised altogether 12 young, but already on August 6th there was only one live individual left. This individual died in January 1920 at a size of $13^1/_2$ mm, but its sex could not be determined macroscopically. The same was the case with another mysid born in aquarium on September 4th 1919 (experiment X); this mysid died on De-

cember 16th of the same year at a length of 9 mm; its curve of growth is shown in the lower right-hand side of fig. 11.

The upper curves represent the growth of 2 ♀♀ of the summer-stock, mentioned in experiments X and XI, and placed in the aquarium when mature; it will be observed that in this instance the growth is very slight.

Upon comparing these curves with the curve, which would be obtained by inserting in fig. 11 the measurements of the largest young to be found in the free nature in the months of June and July (see page 69), it will be noticed immediately that this curve would ascend much steeper than the others. From this can be concluded that several of the mysids born early in the year grow quicker in the free nature than in the aquaria; on the other hand several of the mysids born in June reached such large sizes in the aquaria, that they, as far as size was concerned, very well could have commenced breeding in September; nevertheless as mentioned none of them reached maturity; a similar instance is described in connection with *Gammarus locusta* (page 28).

In order to judge the matter of how many generations *Mysis flexuosa* produces annually, it must first of all be understood, that only very few mysids of the summer-stock reach maturity the same year in which they are born. Calling the winter-stock Generation 0, we saw in the above that the first born young of this stock, i. e. Generation I, appeared in the beginning of June and reached maturity a little past the middle of July of the same year. These produce new young (Generation II), each ♀, however, only 2 broods. It may now be assumed that some of the young, born a little past the middle of June (belonging to Generation I), also reach maturity before the breeding period is at an end, as such mysids, which have been kept in aquarium, reached at the end of the breeding period (in September) a size corresponding to that, at which mysids in the free nature have been found breeding. This was however not the case with mysids born later than the end of June, for which reason such mysids must be assumed to reach winter without having commenced breeding. Thus only the first broods of Generation I reaches maturity, and as the winter-stock continues to breed throughout the month of July, and some individuals even in the month of August, it will be understood that less than the half of Generation I has been able to produce a new generation (Generation II) before the breeding period ends.

None of the mysids of Generation II, which at the earliest begin to appear in the beginning of August, reach maturity before the winter.

Regarding the matter of whether the mysids of the summer-stock, after having been breeding during the autumn can live through the winter and thereupon resume breeding in the following spring, the aquarium observations mentioned here give no information whatever, as all the breeding individuals of the summer-stock die off a few months after the breeding period has ceased. Not before the aquarium observation mentioned page 94 was it proved that this question, as far as *Mysis flexuosa* is concerned, could be replied in the affirmative. Regarding the matters of moulting and mating the information given page 78 pertains also to this species.

Only 2 new generations of *Mysis flexuosa* are thus produced every year, and this, in connection with the fact that more than half the number of Generation I

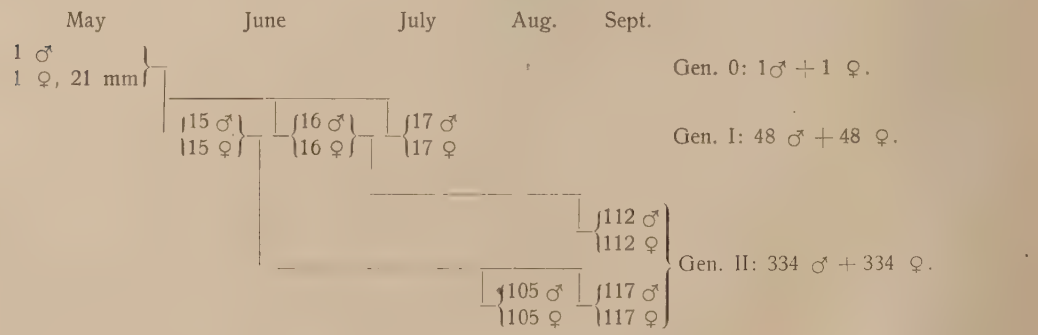
live throughout the winter without having been breeding even once, will explain the conditions stated page 69, according to which the supply of newly born young of *Mysis flexuosa* in opposition to *Mysis inermis*, is comparatively small in the free nature during the months August—September.

The results of a number of countings on eggs and young from the incubatory pouches of *Mysis flexuosa* collected from the Nyborg Fjord are given below.

Length of mother animal:	17 mm	18 mm	19 mm	20 mm	21 mm	22 mm	23 mm	24 mm
4/6 1917		$27_{/3}$ (3)	29 (4)	27 (4)	$30_{/4}$ (5)	$37_{/2}$ (5)	$38_{/8}$ (5)	$40_{/5}$ (5)
25/6 "						$31_{/8}$ (5)	$33_{/8}$ (5)	$34_{/5}$ (4)
30/8 1916	14 (5)	$15_{/6}$ (5)	$18_{/2}$ (5)	25 (1)	25 (2)	27 (2)	25 (1)	

The figures in brackets indicate the number of examined ♀♀; the other figures in the table are the average number of eggs or young, which were found in the incubatory pouches. It will be noted that the number of eggs or young as a whole increase with the length of the mother animal within the same date, but decreases from Jnne till August within the same length of the mother animal. All the examined individuals from June belong to the winter-stock, which most probably also refers to the mysids from August 30th, measuring 21—23 mm; all the others, however, belong to the summer-stock.

In order to form an idea as to the number of descendants of one pair of *Mysis flexuosa* in the course of a breeding period, assuming that all the young live so long, the following scheme may be arranged:



Gen. I—II total 382 ♂ + 382 ♀ = 764 individuals.

As Generation 0 a pair of the earliest breeding mysids from the winter-stock is assigned; the ♀ gets 3 broods of young (Generation I), which are hatched in the beginning of June, the end of June and the middle of July respectively. Assuming that the mentioned ♀ of Generation 0 in May measures 21 mm, the 1st brood will, according to the table on the number of eggs and young, comprise about 30 young; if the mother animal increases in length with 1 mm after each oviposition, the 2nd and 3rd broods will, according to the same table, (the figures for June 25th 1917) amount to $31_{/8}$ and $33_{/8}$ young respectively; assuming that the hatched young comprise equal numbers of ♂ and ♀, a rounding up of the figures will for Generation I give 48 ♂ and 48 ♀ or altogether 96 mysids.

Each of the 15 ♀ of Generation I, 1st brood, will only be able to produce 2 broods of young each (Generation II), the 1st about August 10th and the other in the beginning of September. Reckoning that the mentioned 15 ♀ upon reaching maturity measure 17 mm in length, the will according to the table each get 14 young in the 1st brood, amounting altogether to 210 young, or 105 ♂ and 105 ♀. If the mother animals before the hatching of their 2nd brood have reached a size of 18 mm, they will according to the table each get 15_{16} young, or altogether 234 young, of which 117 are ♂ and 117 ♀. It is very doubtful whether all the young of Generation I, 2nd brood, which are born in the end of June, reach maturity before the breeding period ceases; as mentioned above the aquarium observations have, however, proved that there is a possibility that such mysids may reach maturity in September. Assuming therefore that the 16 ♀ of Generation I, 2nd brood reach maturity in September at a size of 17 mm, they will each be able to produce 1 brood of 14 young (the table p. 86) or altogether 224 young (Generation II) before the breeding period is at an end. Generation II consists thus of altogether 668 mysids.

The offspring of one pair of *Mysis flexuosa* in one breeding period will therefore at the most comprise 764 individuals. It must be remarked that the appearance of the many young in August and September, with which is reckoned in the scheme, does not, as earlier mentioned, correspond to the actual conditions in free nature; the reasons herefore are various. First of all many of the young of Generation I die before reaching maturity, and secondly many of the mysids of the winter-stock (Generation 0) in the free nature do not breed so early as assumed in the scheme, but only reach maturity in June or even in July, for which reason their young are not able to produce a new generation before the winter; a ♀ which reaches maturity in the beginning of July will, according to the method of reckoning employed, at the highest produce 37 individuals before the end of the breeding period, even if it produces three broods of young itself. Finally the scheme assumes that all the mysids born as late as June reach maturity before the breeding period ceases in September; the samples from September (see table 4) show, however, that this is far from the case with all the mysids in the free nature, the mature ♀♀ in the said samples comprising at the highest 1 % of the total number; as the main quantity of Generation I in the free nature is already hatched before the end of June, the percentage of breeding ♀♀ should in September be much higher than it is, if all these mysids reached maturity in September. It is most probable therefore to assume that only a few of the quickest growing mysids born in late June reach maturity the same year in which they are born.

3. *Mysis neglecta.*

The results of the aquarium observations on *Mysis neglecta* are included in the table given below, the manner of proceeding being the same as with the mysids mentioned before. A more detailed account of the observations is to be found in the Danish edition of this book, pages 103—105.

Mysis neglecta.

Winter-stock.

	Eggs	Young without eyes	Young with eyes	Empty
Exp. I 1918	—	—	—	2/5
	23/5	—	—	9/6
	24/6	—	—	10/7
Exp. II 1918	—	—	—	2/5
	21/5	—	—	9/6
Exp. III 1917	—	—	—	7/6
	13/6	—	—	29/6
Exp. IV 1918	5/8	10/8	16/8	29/8
	30/8	—	—	18/9
Exp. V 1917	22/6	—	—	2 —
	25/6	1	—	1 —
	27/6	2	—	— —
	3/7	—	1	— —
	9/7	—	—	1 —
Exp. VI 1917	22/6	7	—	— —
	27/6	—	6	— —
	3/7	—	1	5 —
	9/7	—	—	3 2
	16/7	2	2	— —
	21/7	—	1	1 1
	4/8	1	1	— —
	11/8	—	1	— —

Summer-stock.

	Eggs	Young without eyes	Young with eyes	Empty
Exp. VII 1918	—	—	5/8	—
	10/8	—	—	29/8
Exp. VIII 1918	21/9	2/10	16/10	4/11
Exp. IX 1918	23/9	29/9	12/10	28/10
Exp. X 1918	—	23/9	2/10	8/10
Exp. XI 1917	11/8	2	3	3 —
	20/8	1	2	— 5
	1/9	5	—	— 1
	10/9	—	—	— 3
	22/9	—	—	— 2
	19/11	—	—	— 1

The Results of the Aquarium Observations on *Mysis neglecta.*

Of the mysid species treated here, *Mysis neglecta* is the most difficult to keep alive in the aquaria; many experiments have been commenced, but owing to the death of the mysids shortly after being placed in the aquaria, they have been interupted without result. It proved still mor edifficult to get the ♀♀ to lay viable eggs in the aquaria; this was only obtained in glass bells suspended below the surface of the water (experiments V and VI). Comparatively little information regarding the duration of the period of incubation has therefore been obtained through the aquarium observations. Experiment I shows that in the case of one of the earlist breeding individuals of the winter-stock, 1 month elapsed between the first and second oviposition; as normally the new oviposition immediately succeeds the hatching of the young, the duration of the period of incubation at this time of the year may also be put down to 1 month. According to experiment VI the 2 of the 7 ♀, which on June 22nd carried newly laid eggs in their incubatary pouches, had newly laid eggs the second time on July 16th, i. e. 24 days later; at this time some other 2 had,

however, already young in their incubatory pouches; as they still were without eggs on July 9th, they cannot have got eggs the 2nd time before July 10th, which is 18 days after the 1st oviposition. On August 4th 1 individual had again newly laid eggs, and another one had young without pigmented eyes; they were thus in the same stage as the 4 individuals were on July 16th, there being a whole period of incubation of 19 days between these two dates. In experiment V only 17 days elapsed before a ♀, which was placed in the aquarium on June 22nd carrying young with pigmented eyes, had reached this stage the 2nd time; but the course of the experiment showing that the mysid was at the end of this stage already when placed in the aquarium, 2—3 days must certainly be added to get the correct period of incubation, which will therefore be 19—20 days. Experiment IV shows that in the case of one ♀ of the winter-stock, 24 days elapsed in August before all the young were hatched. Finally experiments VIII and IX show that in the case of the latest breeding ♀ of the summer-stock the period of incubation during September and October lasted at least 35 to 44 days. At the end of May and in the beginning of June the period of incubation lasted thus about 1 month, decreased thereupon gradually during June and July to about 18 days, to again increase in August to 24 days and in September-October to 35—44 days.

The greatest number of broods produced by a ♀ of the winter-stock was 3 (experiment VI); during other observations each ♀ got only 2 broods (experiments II, V and V); in experiments II and III 2 ♀♀ produced only 1 brood of eggs each, though the one of them had lived more than 3 months in the aquarium. The ♀♀ of the summer-stock produced each at the highest 2 broods of eggs (experiments VII and XI). According to the measurement investigations the earliest breeding ♀♀ of the summer-stock reach maturity first time about the end of July; the period of incubation at this time of the year for the winter-stock lasts about 19 days; this refers most certainly to the summer-stock too, coinciding as it does with the fact that the earliest breeding female of the summer-stock in the aquarium observations got eggs the 2nd time on August 10th (experiment VII); other mysids of the summer-stock got eggs the 2nd time in the days between August 11th and September 1st (experiment XI), and of all these mysids it holds good that after the 2nd brood no more ripe eggs were found in the ovaries, though several of them lived in the aquarium for months after. It must be assumed that normally the ♀♀ of the summer-stock breed at the highest twice in succession; the few egg- or young-bearing mysids, which according to the measurement investigations (table 5) are still to be found in the free nature at the end of September and during October, can therefore not belong to the earliest breeding individuals of the summer-stock, as with a period of incubation of 24 days in August, these must have hatched their second brood already in the beginning of September.

Regarding the growth of the young these observations give no information whatever, as all the young hatched in the aquarium died in the course of a very short time, usually before they had increased perceptibly in length. On the other hand the measurement investigations and the aquarium observations on the mature mysids have shown that the growth of *Mysis neglecta* proceeds somewhat slower than the growth of *Mysis flexuosa;* but as the former, consonant to its being a

smaller species, reached maturity when of a size inferior to the latter, the time which elapses before the young of the 2 species reach maturity is about the same.

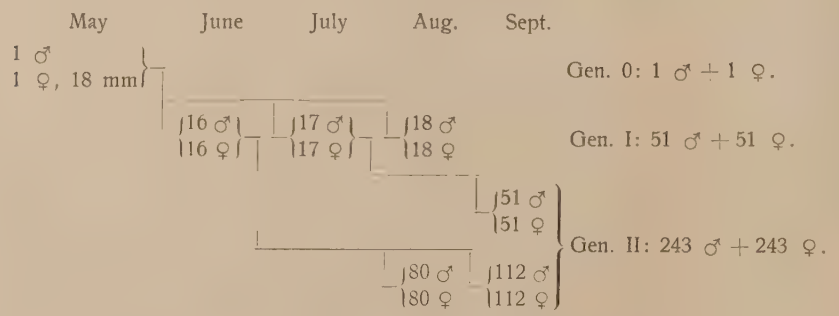
The number of generations is thus the same as with *Mysis flexuosa*, as the earliest born young of the summer-stock appear so late in the year, viz. about the middle of August, that they cannot reach maturity before the breeding period ceases. Also as regards moulting, mating and their faculty of breeding in more than one breeding period, *Mysis neglecta* corresponds to *Mysis flexuosa*.

The results obtained from the counting of eggs and young of *Mysis neglecta* from the Nyborg Fjord are as follows:

Length of mother animal:	13 mm	14 mm	15 mm	16 mm	17 mm	18 mm	19 mm	20 mm	21 mm
$^{4}/_{6}$ 1917					$26_{,4}$ (5)	$31_{,6}$ (5)	$36_{,6}$ (5)	$37_{,8}$ (6)	
$^{25}/_{6}$ —					$24_{,4}$ (5)	$31_{,6}$ (5)	$33_{,6}$ (5)	37 (5)	$42_{,4}$ (5)
$^{11}/_{8}$ 1916		$8_{,0}$ (2)	$9_{,5}$ (2)	14 (1)		17 (2)	$21_{,2}$ (6)	$24_{,5}$ (6)	$25_{,6}$ (5)
$^{18}/_{9}$ 1917	5 (1)	$5_{,8}$ (4)	6 (4)	8 (2)	9 (1)	13 (1)			
$^{27}/_{9}$ 1916			$7_{,8}$ (3)	$10_{,8}$ (3)	$10_{,7}$ (3)	12 (2)	$13_{,5}$ (2)	$14_{,5}$ (2)	

With this species too the number of eggs thus increases with the length of the mother animal, but decreases from the beginning of the breeding period till it terminates. The examined individuals from June all belong to the winter-stock, and the examined individuals from August and September measuring less than 18 mm all belong to the summer-stock, whereas the remainder, as far as could be judged, belong to the winter-stock.

Similarly to what has been done earlier and based upon the present material, we may calculate the production of a pair of the earliest breeding *Mysis neglecta* in the course of a breeding period.



Gen. I—II total: 294 ♂ + 294 ♀ = 588 individuals.

In the above scheme Generation 0 indicates a pair of mysids of the winter-stock; at the end of May the ♀ measures, when it gets eggs the 1st time, 18 mm in length. According to the table of egg-countings for June 4th 1917 such a ♀ contains about 32 eggs; the 2nd brood of eggs of Generation I, which is laid about the end of June, will, according to the table of egg-countings of

June 25th 1917*), comprise 34 eggs, because the mother animal in the meantime has increased in length to 19 mm. The 3rd brood, laid in July when the mysid measures 20 mm in length, comprises 37 eggs according to the table page 90. Assuming that equal number of ♂♂ and ♀♀ are hatched in each brood, the 1st brood of Generation I, hatched at the end of June, will comprise 16 ♀, which reach maturity in late July and produce their first brood in August; assuming the mother animals then to be 15 mm long, they will each get 10 young (see table p. 90) or altogether 160 individuals, of which 80 are ♂ and 80 ♀. The 2nd brood of eggs, which is laid in August, will according to the table page 90 comprise 14 eggs, the mother animals in the meantime having increased in length to 16 mm; the 16 ♀ of Generation I, 1st brood, will thus hatch altogether 224 young, which appear in September as 2nd brood of Generation II.

Whether the 17 ♀ of Generation I, 2nd brood, which are born about the middle of July reach maturity before the winter, is a question that the observations made do not answer directly. As, however, *Mysis neglecta* corresponds in so many ways with *Mysis flexuosa* (the breeding period of the former species only commencing about 10 days later than that of the other species), the 2nd brood of Generation I may be considered to reach maturity before the breeding period ceases. In accordance herewith it has been observed that during September in the free nature ♀♀ are often met with, which still have small incubatory lamellæ, but their large ovarial eggs tend to prove that they will be breeding in the nearest future before the breeding period ceases; as the case is with *Mysis flexuosa*, the 2nd brood of Generation I does not reach maturity before September and accordingly only succeeds in producing one brood of young. Assuming the mother animals to be 15 mm in length when the eggs are laid, they will, according to the table page 90, only get 6 young each; altogether the 17 ♀ will thus be able to hatch 102 young. As none of the mysids of Generation II produce new young before the following year, the production of one pair of *Mysis neglecta* during one breeding period totals 588 individuals.

The description given above relates to only a pair of the earliest, i. e. in late May, breeding mysids of the winter-stock. As the measurement investigations (table 5) show, a great number of mysids, which survive the winter, do not reach maturity before late June or early July. According to experiment VI such individuals will still be able to produce 3 broods of young, viz. 1st brood about the middle of July, the 2nd brood about the beginning of August and the 3rd brood late in August; probably, however, the most of them die before the middle of August, and they will therefore only produce 2 broods of young; measurement lists for $^{13}/_{8}$ 1917, $^{30}/_{8}$ 1916 and $^{30}/_{8}$ 1917 (not included in table 5) show that only 1 breeding ♀ of 296 measured mysids of the winter-stock remained. Each of the young produced by these late breeding mysids, the first-born of which according to the above reach matuirty at the earliest in September, will thus at the highest be able to produce 1 brood of young before the breeding period ceases, and the most of them, viz. all of the 2nd and 3rd broods, do not reach maturity before the winter. As furthermore only a few eggs and young, according to the table page 90, are produced by each ♀ so late in the year, it will be understood that the latest breeding ♀♀ of the winter-stock produce an offspring, which is much less numerous than the one just calculated. A ♀ measuring 18 mm and breeding first time in the late June will thus, even if it produces 3 broods of young itself, at the most produce an offspring amounting to 172 individuals.

*) In the present scheme of the production of one pair of mysids, as well as in the preceding ones of the same kind, the superscriptions May, June etc. only indicate the time when the young appear, *not* when the eggs are laid.

The Size of Production.

A. In the aquaria.

In analogy with the experiment mentioned page 45 relating to *Gammarus locusta*, a feeding experiment was made with a stock of mysids during a whole year in one of the large cement reservoirs, which measured 1 sq. m at the base. On July 31st 1917 about 300 mysids, all belonging to the summer-stock, were caught in the Nyborg Fjord. They were roughly divided into two equal portions, the one of which was placed in the aquarium, while the other was preserved in alcohol for later measurement and weighing purposes. The results obtained are included in column „July 31st 1917" of the bystanding table; for comparison the weight of the animals is computed to rough weight. As will be observed the sample, which on account of the manner of proceeding employed cannot claim to represent the exact number, but certainly the size and stage of development of the mysids in the aquarium, contains representatives of the 3 *Mysis*-species hitherto mentioned; only a few of the largest ♀♀ are breeding yet, the other ♀♀ not having reached maturity. Two months later, on October 1st, all the mysids were taken out of the aquarium, measured and weighed while alive, and thereupon returned to the aquarium. The table shows that the breeding period now has ceased, there being only two ♀ of *Mysis inermis* still breeding. There were found 10 adult ♂ of *Mysis flexuosa*, the 6 of which had fully developed pleopods of the 4th pair, and 18 ♀ of which the 16 had large fallen-in incubatory lamellæ, plainly showing that they had been breeding quite recently; most probably a number of the originally immature ♀♀ placed in the aquarium have in the meantime reached maturity. The same refers to *Mysis neglecta*, the 40 ♂ of which all were fully developed; of the 21 ♀ the 18 largest individuals had fallen-in incubatory lamellæ. Likewise all the *Mysis inermis* indicated as ♀ or ♂ were mature or had recently been breeding. A great number of young had been hatched in the aquarium, so that the number of *Mysis flexuosa* and *neglecta* in the course of the 2 months had increased to the five-double, whereas *Mysis inermis* had only increased to the double. The aggregated weight of all three species had during the same period increased from 4 g to 7 g, as likewise all the mysids had increased considerably in size.

To distinguish between *Mysis flexuosa* and *Mysis neglecta* was already on October 1st a very difficult matter in reference to the group of young, because many young of the latter species, which are strongly pigmented in the free nature, had turned an exceptionally light colour, which was nearly identical to the light colour of the bottom of the cement aquarium, and for this reason they were very difficult to distinguish from the young of *Mysis flexuosa*. When the mysids again were taken out for examination on April 25th 1918, it was observed that a sorting between *Mysis flexuosa* and *neglecta*, especially in reference to the small individuals, was now impossible without the aid of a microscope; this is the reason why they are not kept apart in the table. Only 6 live individuals of *Mysis inermis* remained, and of these the 5 were ♂ measuring 10—11 mm and the 1 a ♀ measuring 11 mm; these mysids are also counted together with the others in the table. The largest of the mysids, viz. the small group of fully developed ♂♂ measuring 20—22 mm and

mm	July 31. 1917.																October 1. 1917.																April 25. 1918.					July 21. 1918.					Septbr. 23. 1918.				
	M. flexuosa.					M. neglecta.					M. inermis.						M. flexuosa.					M. neglecta.					M. inermis.																					
	♂	♀ w. eggs	♀ no eggs	Young	Total	♂	♀ w. eggs	♀ no eggs	Young	Total	♂	♀ w. eggs	♀ no eggs	Young	Total		♂	♂ no eggs	Young	Total		♂	♂ no eggs	Young	Total		♂	♀ w. eggs	♀ no eggs	Young	Total		♂	♀ w. eggs	♀ no eggs	Total		♂	♀ w. eggs	♀ no eggs	Young	Total		♂	♀ w. eggs	♀ no eggs	Young	Total
4	—	—	—	—	—	—	—	—	1	1	—	—	—	6	6		—	—	—	—		—	—	3	3		—	—	—	1	1		—	—	—	—		—	—	—	—	—		—	—	—	4	4
5	—	—	—	—	—	—	—	—	1	1	—	—	—	9	9		—	—	—	—		—	—	3	3		—	—	—	4	4		—	—	—	—		—	—	—	20	20		—	—	—	1	1
6	—	—	—	—	—	—	—	—	2	2	—	—	—	4	4		—	—	4	4		—	—	16	16		—	—	—	4	4		—	—	—	—		—	—	—	51	51		—	—	—	5	5
7	—	—	—	—	—	—	—	—	4	4	—	—	—	5	5		—	—	18	18		—	—	32	32		—	—	—	22	22		—	—	—	—		—	—	—	40	40		—	—	—	27	27
8	—	—	—	1	1	—	—	—	2	2	—	—	—	10	10		—	—	16	16		—	—	22	22		—	—	—	24	24		—	—	—	—		—	—	—	16	16		—	—	—	76	76
9	—	—	—	1	1	—	—	—	1	1	4	—	2	3	9		—	—	4	4		—	—	11	11		—	—	—	30	30		—	—	—	—		—	—	—	—	—		—	—	—	59	59
10	—	—	—	1	1	—	—	—	1	1	13	—	2	—	15		—	—	14	14		—	—	20	20		4	—	—	6	10		4	—	—	4		—	—	—	—	—		—	—	—	34	34
11	—	—	—	2	2	—	—	—	2	2	3	2	—	—	5		—	—	21	21		—	—	33	33		11	2	1	1	15		5	—	1	6		1	—	—	—	1		—	—	—	10	10
12	—	—	—	2	2	7	—	1	1	9	—	3	—	—	3		—	—	16	16		—	—	45	45		1	—	9	—	10		5	—	3	8		1	—	—	—	1		—	—	—	8	8
13	1	—	1	—	2	12	—	2	—	14	—	—	—	—	—		—	—	2	2		—	—	18	18		—	—	1	—	1		5	—	6	11		—	—	—	—	—		—	—	2	13	15
14	1	—	2	—	3	5	—	4	—	9	—	—	—	—	—		—	—	1	1		18	—	1	19		—	—	—	—	—		10	—	6	16		—	—	—	—	—		—	—	2	9	11
15	1	—	1	—	2	1	1	2	—	4	—	—	—	—	—		—	—	—	—		21	4	—	25		—	—	—	—	—		20	—	8	28		3	—	2	—	5		—	—	4	9	13
16	1	—	1	—	2	—	1	1	—	2	—	—	—	—	—		—	—	2	2		—	5	—	5		—	—	—	—	—		17	—	13	30		11	—	5	—	16		1	—	1	8	10
17	1	1	1	—	3	—	—	—	—	—	—	—	—	—	—		2	—	1	3		1	12	—	13		—	—	—	—	—		7	—	9	16		3	2	3	—	8		—	1	—	3	4
18	—	4	—	—	4	—	—	—	—	—	—	—	—	—	—		3	—	—	3		—	—	—	—		—	—	—	—	—		1	—	9	10		—	6	10	—	16		—	—	1	—	1
19	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—		5	2	—	7		—	—	—	—		—	—	—	—	—		—	—	3	3		—	5	2	—	7		4	—	—	—	4
20																	—	3	—	3		—	—	—	—		—	—	—	—	—		5	—	1	6		1	3	—	—	4		1	1	—	—	2
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	4	—	4		—	—	—	—		—	—	—	—	—		2	—	—	2		1	1	—	—	2		1	—	—	—	1
22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	9	—	9		—	—	—	—		—	—	—	—	—		2	—	—	2		—	1	1	—	2		—	—	—	—	—
23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	—		—	—	4	4		—	—	—	—	—		—	—	—	—	—
24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	—		—	—	3	3		—	3	—	—	3		—	—	—	—	—
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—		—	—	—	—		—	—	—	—	—		—	1	2	3		—	—	1	—	1		—	—	—	—	—
Total	5	6	6	7	24	25	2	10	15	52	20	5	4	37	66		10	18	99	127		40	21	204	265		16	2	11	92	121		83	1	68	152		21	21	24	127	193		7	2	10	266	285
Rough weight	$1_{/12}$ g					$1_{/36}$ g					$1_{/12}$ g						$7_{/10}$ g																$4_{/12}$ g					$4_{/14}$ g					$6_{/13}$ g				

the small group of ♀♀ measuring 23—25 mm, were true *flexuosa;* one of these ♀♀ was seen to be carrying eggs in its incubatory pouch, though in the free nature the breeding period had not yet commenced; the remainder had large breeding lamellæ and nearly ripe eggs in the ovaries; they were thus going to breed within a short time. Altogether there were 10 such large *flexuosa*-♀, and from what has been experienced earlier, there can be no doubt but that they are identical with the 10 of the 18 *flexuosa*-♀, which on October 1st 1917 measured 19—22 mm in length and in the table are separated from the others by a little space. As stated in the above all these mysids, 2 individuals excepted, were spent individuals of the summer-stock, which had been breeding at the end of the breeding period, viz. during August-September 1917. Likewise at the least some of the 9 ♂ measuring 20—22 mm must be individuals, which were mature already on October 1st 1917. This is therefore the first instance which proves that mysids of the summer-stock can breed in the aquarium in more than one breeding period. It is evident that the 10 mature or nearly mature *flexuosa*-♀ from April 25th cannot belong to the group of young from October 1st, as in this case some of these mysids should have grown from 12 to 22 mm, i. e. 10 mm, in the course of the winter, which is contrary to the experiences gained earlier; likewise if all the ♂♂ belonged to the group of young from October 1st, some of them should have grown 7 mm, which is a most improbable quick growth for the cold season. Of the true *neglecta* only one ♀ was nearly mature; this one too seems to be one of the spent individuals, which on October 1st measured 15—17 mm in length. In the course of the winter season no young had appeared and a great number of the mysids had furthermore died off, whereby the stock was reduced from 513 individuals, weighing 7 g on October 1st, to 152 individuals, weighing 4,2 g on April 25th. 361 individuals have thus died off in the meantime; their average weight can be put down as $\left(\frac{7_{10}}{513} + \frac{4_{12}}{152}\right) : 2 = 0{,}02031$ g pr. individual, or altogether 7,33 g; since October 1st the weight of the stock has thus in reality increased to $7{,}33 + 4{,}2 = 11{,}53$ g in the course of the winter-season.

When the stock on June 21st 1918 was again taken out of the aquarium for examination, the breeding activity was in full swing. There were now only 2 *Mysis inermis* left, viz. 2 ♂ measuring 11 and 12 mm. Among the other mysids the 2 largest ♂ and the 2 largest ♀ without eggs, which were spent individuals, as well as 6 breeding ♀ measuring 20—24 mm in length, could all be determined as *Mysis flexuosa;* of these 3 of the breeding ♀ measuring 24 mm and 1 of the spent ♀ measuring 25 mm were survivors of the group of mature or nearly mature *flexuosa*-♀, which on April 25th of the same year measured 23—25 mm. The other adult mysids were true *Mysis neglecta,* but amongst the young both species were found mixed together. There were altogether 66 adult wintered mysids; 86 individuals have thus died off since the last examination. As the entire stock now weighs 4,4 g, of which the young take the 0,7 g, each of the 86 dead individuals must have weighed approximately $\left(\frac{4_{12}}{152} + \frac{3}{66}\right) : 2 = 0{,}04152$ g, or altogether 3,57 g. The 4,2 g mysids from April have thus in the course of 2 months increased to a weight of $4{,}4 + 3{,}57 = 7{,}97$ g.

On September 23rd 1918 all the mysids were taken out of the aquarium, killed in alcohol and thereupon measured and weighed carefully; there were now only *Mysis flexuosa* and *neglecta* left. The entire winter-stock was gone, and 2 ♀ of the summer-stock were found breeding, these being 1 *Mysis neglecta* measuring 17 mm and 1 *Mysis flexuosa* measuring 20 mm; this is the first time I have succeeded in getting mysids of these two species, born in aquarium, to become mature before the winter. Also among the ♀♀ without eggs a few were found with signs typical for mysids, which have recently been breeding. As well here as in the group of young, *Mysis flexuosa* and *Mysis neglecta* were found, though the latter species predominated, but it was impossible to distinguish them without counting the spines on the tail plate. The 285 mysids totalled in weight 6,8 g; it is to be noted that the growth of the summer-stock in the aquarium, when compared with the growth of the aquarium's stock during August—September 1917, has been comparatively small. Also the number of young, which have appeared in the aquarium in the course of the breeding period 1918, has been comparatively small, as a production of 285 mysids from 69 ♀ only gives 4 young to each.

In conformity with *Gammarus locusta* the quantitative result of the rearing of mysids in aquaria does not at all correspond with the theoretically calculated size of the production stated pages 80, 87 and 91, especially on account of the heavy rate of death among the animals in the aquaria. As furthermore the mysids altogether are much less prolific than *Gammarus locusta*, a rearing of them as food for fish would hardly pay.

In the aquarium observations described above the mysids were fed with weighed-off food comprising partly the fresh minced soft parts of mussels, and partly of fresh algæ. To prevent the latter in growing, the aquarium was kept dark by being covered with a lid. The figures stated below give information regarding the quantity of mussels and algæ consumed in the course of the different months throughout the year. It will be observed that a much less amount of food is consumed during the winter months than during the summer months, which conforms with the growing of the mysids proceeding slower during the winter.

Weight in g of food consumed and of mysid stock in aquarium. From July 31st 1917 till September 23rd 1918.

	Aug.	Septb.	Octb.	Nov.	Decb.	Jan.	Febr.	March	April	May	June	July	Aug.	Septb.
Food *Mytilus*	43,5	42,3	26,0	21,0	24,0	12,0	18,0	12,0	24,0	28,0	40,0	60,0	53,0	10,-
Food Algæ	23,-	20,-	53,2	20,0	0,-	20,0	20,0	20,0	20,0	20,0	20,0	20,0	20,0	20,0
Live mysids	4,0 g		7,0 g						4,2 g	4,14 g			6,8 g	
Dead mysids							7,88 g			3,57 g			3,- g	

The „useful effect" during the months of August and September 1917 was about $^1/_{73}$, there being during this time produced 3,0 g mysids, whose dry matter percentage is 9,5, from a quantity of food amounting to 129,6 g algæ and mussels, the dry matter percentage of which is about 16. From October 1st till October 25th

there were consumed altogether 131 g mussels and 173,2 g algæ, whereby the weight of the mysids increased from 7,0 g to 11,53 g; thus 4,53 g mysids were produced, this giving a „useful effect" for the winter of only $^1/_{113}$. From April 25th till June 21st 1918 there were consumed altogether 54 g mussels and 40 g algæ. From this was produced 7,97 ÷ 4,2 g = 3,77 g mysids, which gives a „useful effect" of $^1/_{42}$. Upon the conclusion of the experiment on September 23rd 1918 the entire winter-stock had died off; the summer-stock, which on June 21st of the same year only consisted of the group of young, weighing 0,7 g, had grown up to a weight of 6,3 g, whereby there since June 21st has been produced 6,3 ÷ 0,7 = 5,6 g mysids. As at the same time 143 g mussels and 60 g algæ had been consumed in the aquarium, we get a „useful effect" for this period of $^1/_{61}$.

In the course of a little more than a year there has altogether been consumed 403,8 g mussel-meat and 317 g algæ, and in the course of the same time there was produced altogether 16,9 g mysids in the aquarium, which gives a „useful effect" of about $^1/_{72}$. The „useful effect" is thus much less among the mysids than among *Gammarus locusta*. It must, however, be noted that minced mussel-meat is much more liable to decay than whole opened mussels, with which *Gammarus locusta* was fed; though it was not found necessary on account of the development of bacteria to change the water during the experiment with the mysids, it is evident that a part of the food has not been consumed, but has decayed; the stated figures which indicate the „useful effect" are therefore only minimum values. When at the end of the experiment the water of the aquaria was taken out, it was observed that some detritus had gathered at the bottom of the reservoir; it was, however, only a matter of a few grammes.

The relation between the increase in weight of the mysids and the food consumed, both values being conputed to dry matter, varies thus between $^1/_{42}$ and $^1/_{113}$; it was greatest during the spring and smallest during the winter, at which time the mysids consumed about $^1/_3$ of what was consumed during the summer. In the aquaria which covered an area of 1 sq. metre, 16,9 g mysids were developed in the course of 14 months.

B. In the Nyborg Fjord.

Besides gammarids a number of mysids were caught in the quantitative fishing experiments mentioned page 53, and similar to the gammarids the hatched young mysids sought the surface of the water in the evening after dark. In the table below the results from the hand-net draggings mentioned page 53 are gathered, the 3 *Mysis*-species being here counted together.

During the months April—May and November—January hardly anything but adult mysids were caught; the samples from June comprised mostly newly hatched young of *Mysis inermis*, and during July—September the majority of *Mysis*-young were newly hatched individuals. As estimated minimum-value, the annual production of mysids in the Nyborg Fjord may therefore be reckoned as the sum of the largest figures for each of the months June—September in the table, i. e. 0,23 + 0,09 + 1,43 + 0,79 = 2,54 g per sq. metre. Probably it is somewhat larger, as a great number of mysids, which are devoured by other animals, are not included in

Place	Algæ		Water surface	Algæ		Water surface	Algæ	Water surface	Algæ		
Date	17/4 1917	5/5 1917	7/5 1918	23/6 1917		31/7 1918	16/8 1917	22/8 1917	2/9 1917	26/11 1917	22/1 1917
	p. m.	p. m.	Even.	Noon	Even.	Even.	Even.	Even.	Even.	p. m.	p. m.
Surface treated	$27_{,5}$ m²	2 m²	1 m²	1 m²	1 m²	2 m²	1 m²	2 m²	1 m²	1 m²	2 m²
Number of mysids per m²	2	6	0	10	26	23	11	61	147	14	$0_{,5}$
Rough weight in g per m²	$0_{,12}$	$0_{,23}$	0	$0_{,12}$	$0_{,23}$	$0_{,09}$	$0_{,08}$	$1_{,43}$	$0_{,79}$	$0_{,44}$	$0_{,01}$

these figures. However, there is no doubt that the annual aggregated production of the 3 *Mysis*-species is less than the annual production of the *Gammarus locusta* alone; partly the mysids are much less prolific animals than *Gammarus locusta*, partly the aggregated offspring of a pair of each *Mysis*-species is far less in number than the offspring of one pair of *Gammarus locusta*, and partly the mysids are comparatively small animals, and their weight is therefore also comparatively small.

The periodically repeated examinations of the Zostera-regions in the different Danish fjords by means of a quantitative hand-net as mentioned p. 1 have proved that the greatest numbers of our 3 common *Mysis*-species are met with in the autumn, during August and September, when the young of as well summer-stock as winter-stock have appeared. In the Nyborg Fjord during this season 473 individuals were found per sq. metre, in Nykøbing Bay, Mors, 573, in the Holbæk Fjord 271 and in Svendborg Sound 213 individuals per sq. metre; another year no less than 8,1 g mysids per sq. metre were found in Svendborg Sound. The investigations have been carried on during 3 years (1914–1916) and gave the following figures, which represent the average of mysids found during these 3 years (all the figures are roug hweight):

The Nyborg Fjord	1/3	m	depth:	1,50 g
Svendborg Sound	2/3	-	—	4,93 -
The Holbæk Fjord	1/3	-	—	3,80 -
The Limfjord	1	-	—	3,78 -

The figures may be used for mutual comparison as minimum values for the annual production; this production is of course somewhat larger; thus the figure page 96 for the Nyborg Fjord, viz. 2,54 g per sq. metre, is certainly more correct. Assuming that the mysids of the Nyborg Fjord only are to be found from the shore to a depth of 5 m, the last mentioned figure (see page 54) gives an annual production of the 3 *Mysis*-species in the Nyborg Fjord of 12700 kg, which is only a quarter of the amount calculated for *Gammarus locusta*, viz. 50000 kg.

Other Species of *Mysidæ*.

The species mentioned page 57, which appear in the Nyborg Fjord together with the 3 species mentioned above, have occasionally been subject to measurement investigations, which show that in reference to biological conditions they conform with these 3 species.

Thus only large individuals of *Mysis spiritus* were found on April 17th in the Nyborg Fjord, and they had not yet reached maturity; the ♀♀ had, however, ovarial eggs and the ♂♂ well developed pleopods of the 4th pair. On May 8th large breeding ♀♀ were found; in July all the wintered individuals had reached maturity and numerous young were hatched. On August 18th many breeding individuals were still found, and judging by their size (♂♂ measuring up to 16 and ♀♀ up to 17 mm) they must belong to the winter-stock; a few smaller ♀♀ measuring 11 mm and ♂♂ measuring 10 mm, all of which were nearly mature, suggested that also a part of the summer-stock reached maturity before the breeding period ceased. This species is not common in the Nyborg Fjord; as an instance of the great numbers of which they can be found elsewhere, especially in shallow bays with clean sand bottom, it may be stated that in the Flaske Bay 4000 *Mysis spiritus* within an area of 100 sq. metre were caught by means of a quantitative fishing implement on September 1st 1913; the mysids weighed altogether 24,8 g.

In the Nyborg Fjord several breeding ♀♀ of *Mysis vulgaris* were found already on April 14th; on May 11th the most of the wintered individuals had reached maturity, but no young had yet appeared. In July and August large breeding ♂♂ and ♀♀ measuring 12 and 14 mm respectively were found, and besides these also a number of young, the most of which were newly hatched; in a sample from Kerteminde the largest young measured about 6 mm on August 18th. During November and January no mature *Mysis vulgaris* were found; whether the summer-stock reached maturity before the breeding period ceased could not be substantiated. This species is found in the shallow water close to the shore; during the winter this more hardly form predominates among all other crustaceans in the shallow waters of Svendborg Sound and the Nyborg Fjord.

The wintered stock of *Macropsis Slabberi* in the Nyborg Fjord had on April 11th not yet reached maturity. On June 30th only large breeding individuals measuring 10—12 mm and all belonging to the winter-stock were found by Samsø, but about the end of August, when this species immigrates in great numbers to the low waters of the Nyborg Fjord, a great stock of smaller breeding individuals measuring 7—10 mm as well as several breeding individuals measuring up to 14 mm in length were found; the former of these belong without doubt to the summer-stock. The breeding period ceased in October, as no breeding individuals were found during the winter months.

Mysis mixta has been examined earlier by Apstein (see page 2); by means of a quantitative fishing implement about 6000 individuals of this species were caught outside the Nyborg Fjord on August 25th 1913 just above the sea bottom on an area of 50 sq. metres, which gives 120 individuals per sq. metre.

Resumé.

Our 3 common species of *Mysidæ*: *Mysis inermis*, *flexuosa* and *neglecta* are all annual. The breeding period of the first named species lasts from the end of April till the end of October, of *flexuosa* from the middle of May till some time in October, and of *neglecta* from the end of May till the end of October. The wintered individuals — the winter-stock — all die off in the course of July—August; before this each ♀ hatches up to 3 broods of eggs. The winter-stock of *Mysis inermis* produces at the most 3 generations, the other two species 2 generations. In opposition to the winter-stock all the mysids, which have not yet wintered, are called the summer-stock. The young of these 3 species born earliest in the year appear at the end of May, the beginning of June and the end of June respectively; they reach maturity in the beginning of July, the middle of July and the end of July respectively. The earliest born ♀♀ of the summer-stock of *Mysis inermis* may each produce up to 5 broods of young, whereas each ♀ of the summer-stock of the two other species can only hatch 2 broods. The ♀♀ of the summer-stock always reach maturity at a much smaller size than the ♀♀ of the winter-stock, and for this reason the first named were usually very easy to distinguish from the last named. A number of the ♀♀ of the summer-stock may, however, be assumed to winter and resume breeding in the beginning of the breeding period of the following year.

During the warmest summer-time the period of incubation of *Mysis inermis* lasted a little more than 2 weeks, and of the other two species about 3 weeks, but at the beginning and at the end of the breeding period most often about 4 weeks, and at times even 5 weeks elapsed. Immediately subsequent to each hatching in the breeding period a new deposition of eggs took place.

The growth (figs. 11 and 12) proceeds slowly during the winter and quickly during the summer. The ♀♀ grow quicker and become larger than the ♂♂. The mysids born earliest in the year reached maturity in the course of about $1^1/_2$ months; in regard to those born later in the year a longer time elapsed before maturity was reached.

The mating has not been observed. Every new deposition of eggs was combined with a moulting of the ♀. The number of eggs, which each ♀ deposits, is dependent partly on the size of the mother animal and partly on the season of the year; the larger the ♀♀ were at the same time of the year, the greater was the number of eggs to be found in their incubatory pouches, whereas the later in the year the egg-laying took place, the smaller was the number of eggs each ♀ of the same size got. See furthermore the tables pages 79, 86 and 90.

According to calculations made, a pair of mysids of the winter-stock would in the course of one breeding period be able to produce the following number of young:

Mysis inermis:	1306	individuals	(3	generations)	
Mysis flexuosa:	764	—	(2	—	)
Mysis neglecta:	588	—	(2	—	)

The food consists of detritus, fresh plants and animal nourishment. On feeding the mysids in aquaria with mussels and fresh algæ it was observed that less was

consumed during the winter than during the summer. The „useful effect" varied between $^1/_{42}$ and $^1/_{113}$ (page 95—96).

The annual production in the Nyborg Fjord can be estimated at abt. 2,54 g (rough weight) per sq. metre as a minimum value. In other Danish fjords there have been found up to 8,1 g mysids per sq. metre. The biology of different other Danish mysids corresponds very closely to that of the species treated here; the same refers to *Mysis mixta* examined in the Baltic Sea by Apstein.

On the Biology of some other Crustaceans from fresh and salt Waters.

As a comparison to the biology of the above treated amphipods and mysids the following litterature on the biological conditions of other crustaceans may finally be stated here.

Th. Mortensen (17) has proved through measurements and aquarium observations that our common prawn, *Palæmon Fabricii* Rtk. is at the least biennial; it breeds from the beginning of May till the end of July or the beginning of August. Many of the ♀♀, especially the large individuals, produce 2 broods of eggs in the breeding period, the one immediately succeeding the other, and the ♀♀ moult immediately before depositing their eggs; the hatching of the eggs at the beginning of a breeding period lasts about one month, but according to the author's statement it is probably shorter the warmer the water is. The growth proceeds only during the warm season and the prawns reach maturity when 1 year old. The mating has not been observed; the number of eggs increases with the size of the mother animal and varies from 300 to abt. 2600 with each ♀.

Ehrenbaum (7, 1890) has examined the shrimp, *Crangon vulgaris* Fabr., by the Northsea coast of Germany. Every year two ovipositions take place, viz. in April—June and in October—November. The hatching of the eggs during the summer lasts 4 weeks, but during the winter it lasts 4—5 months. The author is of the opinion that the shrimp may reach an age of 3 years and that it becomes mature when about 1 year old. Each ♀ lays about 5000 eggs. With this species the moulting takes place immediately prior to the oviposition, and each ♀ produces two broods of eggs in succession. The material published from this paper is, however, hardly sufficient to serve convincing as to the correctness of the author's conclusion. According to Monaghan (16) the shrimp by the English coast seems most essentially to breed during April—August.

Williamson (26, 1900 and 1904) examined the Edible Crab *(Cancer pagurus* L.) from the North Sea by means of measurements and in aquaria. The mating takes place during the autumn subsequent to the female's moult. The eggs are not laid until the following winter (November—January), about 14 months later, and the hatching

of the eggs lasts about half a year. Each ♀ lays from 460 000 to 3 000 000 eggs. The animals are mature in their 6th year, and they can live till they are 9 year old.

The same author (26, 1903) relates in reference to the Shore Crab *(Carcinus mœnas* Leach), that it lays eggs throughout the whole year, but mainly during the summer. Mating does not take place until the moulting of the ♀ is at an end. Moulting takes place more often during the summer than during the winter. The animals reach maturity in their second year. They only seem to get eggs once a year, and reach an age of about 4 years.

Regarding our common lobster *(Homarus vulgaris* M. Edv.) an extensive literature is to be found, especially by Ehrenbaum (7, 1903) and Appelløf (1). By Norway's coast this species reaches maturity when about 5 years old, and the mature ♀♀ moults every other year, in the Kattegat every year (Trybom). Also the oviposition takes places every other year in Norway; by England, Scotland and Helgoland, however, probably every year (Cunningham, Williamson, Ehrenbaum). Subsequent to the hatching of the young the moult takes place; the mating has not been observed, but most probably it takes place immediately after the female's moult (Ehrenbaum (7)). The eggs are laid during the summer and the hatching lasts about 1 year.

Regarding the crayfish *(Astacus fluviatilis* Fabr.) too an extensive literature is to be found, especially by authors as Huxley, Drøscher, Schikora, Trybom and Nordqvist. This species is said to reach an age of about 10 years. The ♂ probably reaches maturity already at the age of 3 years, and the ♀ at the age of 4 years; the moulting of the mature individuals takes place only once (♀) or twice (♂) annually, with the young much oftener. The eggs are laid 13—14 days after mating, which takes place during the autumn (November—December). The hatching of the eggs lasts 6 months, and of the 60—200 eggs, which each adult ♀ lays every year, only 12—20 young are produced. According to Nordqvist the crayfish grows much slower in Sweden than farther southward as e. g. in Germany.

In reference to *Eupagurus prideauxii* Leach from Naples, P. Mayer (15) writes that it has no certain breeding period; he has not observed the fertilization, but is of the opinion that it takes place on the outside, the spermatophores being attached to the ♀ while its ovarial eggs are still immature. The eggs are then not laid before the hatching of the preceeding brood of young is completed, and is independent of moulting or antecedent mating.

M. Faxon (10, pages 303—330) has observed that the ♀ of *Palæmonetes vulgaris* always moulted a few hours subsequent to having hatched its young, and usually during the night.

Kaulbersz (13) has made some aquarium observations on *Asellus aquaticus* in Munich. In the aquaria this species continued breeding throughout the year, but in the free nature the first copulating individuals were observed in January—February and were seldom found later than October—November; if then placed in an aquarium they would immediately commence copulating. The ♀ carries the ♂ in a kind of „riding-position" for 6—8 days, after which mating takes place, the ♂ and ♀ turning over with their ventral sides towards each other. After each completed copulation the ♀ moults; the young are hatched in the course of 3—4 weeks;

when the young are hatched, the ♀ moults again. The moult of either sex is otherwise dependent on age, temperature and amount of nourishment.

From what is stated in the foregoing it will be observed that the temperature is one of the most important biological factors in the biology of all the examined species of crustaceans. By a higher temperature moulting takes place oftener, and accordingly the growth proceeds quicker than by a lower temperature, and therefore the breeding activity is promoted or even only takes place during the warm time. A feature common for all the crustaceans is furthermore that the number of eggs in the ♀ increases with the size of the mother animal. It seems also to be the usual rule that the larger species live longer, propagate more seldom and require a longer period of hatching than the smaller species. The mating, as regards the ♀♀ of most of the species, seems to take place after a moult, and the hatching of the young seems always to be followed by the moulting of the mother animal. However, for numerous and often very common species such biological details are wanting by means of which these matters can be judged with certainty.

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Table I.

Measurements in mm of *Gammarus locu*

From *Mytilus*-clusters on the pier of the Nyborg harbour.

Each separate measurement comprises the stock of *G. locusta* from abt. 12 liter or $11_{,5}$ kg *Mytilus edulis* by the Nyb

	January 21. 1918.				February 15.1917.			March 8. 1918.				April 14. 1917.			May 18. 1918.				June 7. 1917.			
mm	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Y
1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	31	—	—	—	
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	93	—	—	—	
4	—	—	—	1	—	—	—	—	—	—	10	—	—	—	—	—	—	167	—	—	—	
5	—	—	—	6	—	—	—	—	—	—	14	—	—	—	—	—	—	383	—	—	—	
6	—	—	—	18	—	—	5	—	—	3	17	—	—	—	—	—	—	439	—	—	—	
7	—	—	4	10	1	—	7	3	—	27	10	—	—	—	—	—	1	260	1	—	—	
8	4	—	12	6	1	1	9	13	10	81	2	—	—	—	2	—	11	124	2	—	—	
9	3	2	18	—	2	4	12	28	63	78	—	—	—	—	4	6	13	62	6	1	2	
10	7	4	13	—	6	16	15	48	72	36	—	—	—	—	4	20	9	39	4	7	3	
11	8	6	5	—	10	31	8	45	30	6	—	1	7	1	5	37	5	12	2	16	2	
12	7	5	4	—	14	43	4	26	8	3	—	1	24	—	10	38	4	—	1	23	1	
13	5	3	2	—	22	22	1	17	10	—	—	3	40	1	14	23	—	—	3	22	2	
14	7	3	1	—	20	14	2	13	3	—	—	6	41	—	18	12	1	—	6	11	3	
15	4	—	—	—	24	5	1	10	2	—	—	7	20	—	15	7	—	—	8	4	1	
16	5	—	—	—	25	—	—	5	—	—	—	16	14	—	13	4	—	—	10	2	—	
17	—	1	—	—	12	—	—	2	—	—	—	19	3	—	7	4	2	—	13	1	—	
18	2	—	—	—	5	—	—	2	1	—	—	20	1	1	5	9	1	—	5	1	—	
19	—	—	—	—	1	—	—	—	—	—	—	16	2	—	1	2	—	—	4	—	—	
20	—	—	—	—	1	—	—	—	—	—	—	10	3	—	1	1	—	—	3	—	—	
21	—	—	—	—	1	—	—	—	—	—	—	6	1	—	2	1	—	—	—	—	—	
22	—	—	—	—	—	—	—	—	—	—	—	4	1	—	3	—	—	—	—	—	—	
23	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	
24	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	
25	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	
26	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	
27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	
	52	24	59	41	145	136	64	212	199	234	53	113	158	3	105	164	47	1610	69	88	14	3

rom *Mytilus* in Nyborg Fjord.

harbour, excepting however the measurement taken on ⅟₇ 1917, which only comprises a sample from such a stock.

July 4. 1917.				August 4. 1916.				September 15. 1917.				October 3. 1917.			November 4. 1916.			November 21. 1916.			
♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young
–	–	–		–	–	–	–	–					–	–	–	–	–				–
–	–	–	–	–	–	–	6	–	–	–	8	–	–	115	–	–	–	–			–
–	–	–	14	–	–	–	26	–	–	–	80	–	–	246	–	–	–	–	–	–	–
–	–	–	33	–	–	–	52	–	–	–	246	–	–	179	–	–	3	–	–	–	2
–	–	–	69	–	–	2	66	–	–	1	292	–	–	306	–	–	7	–	–	–	3
–	–	–	108	–	2	14	58	14	1	46	304	1	1	476	–	–	12	–	–	–	15
–	–	–	70	7	4	35	20	41	3	187	182	23	41	432	1	27	6	–	–	–	20
1	6	10	35	13	11	38	4	73	3	182	42	31	142	120	2	45	–	–	–	41	12
6	15	16	1	14	15	33	–	88	11	86	–	65	80	–	9	41	–	4	–	64	5
12	6	22	–	19	9	27	–	58	1	21	–	71	36	–	21	29	–	15	–	100	2
16	4	11	–	11	5	12	–	27	–	11	–	33	5	–	16	16	–	21	–	78	–
17	2	3	–	10	3	7	–	22	–	1	–	24	2	–	14	11	–	34	–	31	–
10	1	1	–	11	–	2	–	7	–	–	–	2	–	–	11	2	–	35	2	16	–
2	1	–	–	6	–	–	–	6	–	–	–	5	–	–	13	–	–	18	1	3	–
3	1	–	–	3	–	–	–	1	–	–	–	1	–	–	4	1	–	17	1	–	–
–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	2	–	–	5	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	3	–	2	–
1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	2	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	3	–	–	–
68	36	63	330	95	49	170	232	337	19	535	1154	256	307	1874	99	172	28	157	4	335	59

Sample comprising abt. ⅟₉ of material.

Table 2.

Measurements in mm of *Gammarus locusta*

From algæ and Zostera near th

mm	January 21. 1918.				February 16. 1917.				March 7.—12. 1918.				April 20.—23. 1918.				May 15.—16. 1918.				June 4. 1917.			
	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♀	♀ with eggs	♀ without eggs	Young
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	189	—	—	—	92	—	—	—	136
3	—	—	—	1	—	—	—	1	—	—	—	7	—	—	—	437	—	—	—	79	—	—	—	98
4	—	—	—	7	—	—	—	8	—	—	—	8	—	—	—	555	—	—	—	106	—	—	—	14
5	—	—	—	12	—	—	1	17	—	—	—	13	—	—	—	254	—	—	—	74	—	—	—	3
6	—	—	—	17	—	—	6	21	—	—	—	12	—	—	—	27	—	—	—	73	—	—	—	—
7	1	—	—	2	2	—	16	7	—	—	4	9	—	—	1	4	—	—	1	17	—	—	—	—
8	1	—	7	—	10	—	20	2	3	—	3	1	1	—	5	2	—	—	1	14	—	—	—	—
9	—	—	7	—	16	—	20	—	4	2	4	—	5	—	13	—	1	1	1	2	1	—	—	—
10	—	—	3	—	16	5	16	—	4	1	2	—	4	—	18	—	4	3	1	—	2	2	1	—
11	—	—	—	—	17	5	13	—	4	—	1	—	5	4	21	—	1	3	2	—	3	6	2	—
12	—	—	2	—	15	6	1	—	—	1	2	—	12	5	13	—	3	9	2	—	9	7	6	—
13	2	—	—	—	12	5	—	—	1	—	—	—	8	5	3	—	4	15	1	—	13	10	9	—
14	—	1	3	—	13	3	—	—	—	1	—	—	13	—	1	—	5	14	1	—	15	9	12	—
15	—	—	—	—	10	1	—	—	—	—	—	—	4	3	—	—	7	8	1	—	18	6	6	—
16	—	1	—	—	11	—	—	—	—	1	—	—	3	2	—	—	7	3	1	—	18	—	—	—
17	1	—	—	—	4	—	—	—	—	4	1	—	—	1	1	—	5	1	—	—	13	—	—	—
18	2	1	—	—	5	—	—	—	—	3	—	—	3	1	—	—	5	1	—	—	1	—	—	—
19	—	—	—	—	4	—	—	—	1	—	—	—	1	3	—	—	4	1	—	—	—	—	—	—
20	—	—	—	—	1	—	—	—	—	—	—	—	2	5	—	—	3	1	—	—	—	—	—	—
21	—	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	1	2	—	—	—	—	—	—
22	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—
23	—	—	—	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
26	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
27	—	—	—	—	—	—	—	—	1	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
28	—	—	—	—	—	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
29	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
31	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	8	3	22	39	137	25	93	56	24	13	17	50	70	33	76	1468	50	62	12	473	93	40	36	251

rom algæ in the Nyborg Fjord.

nchorage of the Biological Station.

July 4. 1917.				August 5. 1916.				September 6. 1916.				October 2.—4. 1917.				November 4. 1916.				November 21. 1916.			
♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young
—	—	—	—	—	—	—	13	—	—	—	50	—	—	—	134	—	—	—	—	—	—	—	—
—	—	—	5	—	—	—	70	—	—	—	121	—	—	—	167	—	—	—	1	—	—	—	—
—	—	—	21	—	—	—	98	—	—	—	76	—	—	—	48	—	—	—	11	—	—	—	5
—	—	—	27	—	—	—	92	—	—	—	86	—	—	—	16	—	—	—	21	—	—	—	18
—	—	—	24	1	—	4	66	2	1	2	106	—	—	—	26	—	—	—	34	—	—	—	28
—	—	—	23	2	4	12	34	11	21	3	105	—	1	7	8	—	—	—	34	—	—	—	31
—	2	—	15	11	10	17	4	27	84	13	62	2	—	8	3	—	2	14	17	—	—	—	27
4	2	2	—	14	11	11	—	39	152	14	14	3	1	13	1	—	4	25	—	—	—	—	21
1	4	2	—	14	9	3	—	51	77	10	3	2	3	8	—	1	9	27	—	—	—	2	13
3	4	2	—	12	5	1	—	73	33	6	—	12	3	5	—	2	3	16	—	2	1	3	3
6	2	—	—	5	—	—	—	79	13	2	—	2	—	5	—	3	1	12	—	4	—	2	—
6	—	—	—	4	1	—	—	62	1	—	—	3	—	3	—	6	1	9	—	6	—	1	—
7	—	—	—	5	—	—	—	32	—	—	—	4	—	1	—	6	—	11	—	4	—	2	—
—	—	—	—	—	—	—	—	8	—	—	—	2	—	—	—	8	—	6	—	2	—	—	—
—	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—	14	—	4	—	1	—	1	—
—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	9	—	3	—	5	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—	—	3	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	1	—	1	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
27	14	6	115	68	40	48	377	389	382	50	623	30	8	50	403	69	20	127	118	28	1	12	146

Table 3.

Measurements in mm of *Mysis inermi*

mm	Jan. 21. 1918.			Febr. 20. 1917.			March 7. 1918.			April 14. 1917.			April 20.–24. 1918.				May 15. 1918.			June 4. 1917.			June 25. 1917.			
	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	Young
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
4	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
5	—	—	37	—	—	—	—	—	11	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	12
6	—	—	83	—	—	5	1	—	34	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	7
7	6	—	126	8	1	17	8	3	87	5	2	6	1	—	—	1	—	—	—	—	—	—	1	—	—	3
8	46	—	148	38	6	47	49	23	70	17	25	10	2	—	—	12	—	—	—	—	—	—	—	—	—	
9	60	1	139	46	19	28	65	59	12	34	36	7	24	—	—	43	3	—	3	—	—	—	—	—	—	—
10	17	6	37	43	66	7	35	60	1	55	52	1	41	—	20	51	18	—	9	15	—	—	1	—	—	—
11	—	7	4	19	32	—	1	26	—	34	52	—	79	—	45	22	35	—	10	41	—	6	1	1	2	—
12	—	4	—	2	7	—	—	1	—	12	29	—	34	—	74	7	10	12	14	24	6	8	1	4	4	—
13	—	—	—	—	—	—	—	—	—	1	12	—	4	3	56	—	—	32	8	—	47	6	1	13	3	—
14	—	—	—	—	—	—	—	—	—	—	1	—	—	3	20	—	—	9	2	—	35	1	—	9	2	—
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	10	—	—	2	—	—
	129	18	579	156	131	104	159	172	215	158	209	25	185	6	215	137	66	54	46	80	98	21	6	29	11	38

rom the Nyborg Fjord.

July 3. 1917.				August 13. 1917.				August 30. 1917.				September 24. 1917.				October 16.–19. 1917.				Novbr. 13. 1917.			Dcbr. 11. 1917.		
♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—			—	—	—
—	—	—	—	—	—	—	6	—	—	—	8	—	—	—	13	—	—	—	10	—	—	—	—	—	—
—	—	—	17	—	—	—	29	—	—	—	17	—	—	—	47	—	—	—	26	—	—	—	—	—	2
—	—	—	27	—	—	—	37	—	—	—	62	—	—	—	76	—	—	—	34	—	—	8	—	—	13
—	—	—	17	—	—	—	31	—	—	—	68	—	—	—	67	—	—	—	49	—	—	66	—	—	36
2	—	—	6	1	—	—	14	6	—	—	32	—	—	—	106	—	—	—	69	—	—	131	—	—	74
43	—	30	6	4	—	—	7	33	22	2	8	2	—	—	98	—	—	—	89	5	—	226	3	—	110
38	1	87	—	119	—	4	—	20	34	4	6	11	4	1	20	1	3	1	44	6	4	284	25	1	115
—	10	59	—	35	7	14	—	—	15	2	2	6	15	4	5	7	8	8	13	7	21	69	22	11	43
—	9	9	—	6	36	2	—	—	1	—	—	—	12	3	2	1	3	7	2	3	23	—	—	16	—
1	—		—	2	10	1	—	—	—	—	—	—	—	—	—	—	—	1	—			-	-	-	-
—	3	—	—	—	5	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—				—	—	
81	29	185	73	167	58	22	124	59	72	8	203	19	31	8	436	9	15	17	336	21	48	784	50	28	395

Table 4.

Measurements in mm of *Mysis flexuosa*

mm	January 21. – 28. 1918.			Febr. 16. 1917.			March 12. 1918.			April 14. 1917.		May 15. 1918.			June 4. 1917.			June 25. 1917.				July 5. 1916.			
	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*) —	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	—	—	—	1
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	67	—	—	—	6
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	12
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10	—	—	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11	—	—	2	1	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	—	—	—	8	—	6	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	1	1	—	6	2	5	1	—	1	4	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—
14	1	5	—	2	7	2	1	1	—	6	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	2	3	—	7	7	—	1	3	—	7	5	—	—	—	1	—	—	—	—	—	—	—	—	—	—
16	2	1	—	9	15	—	4	2	—	13	5	—	—	—	1	—	—	—	—	—	—	—	—	—	—
17	13	3	—	11	20	—	11	1	—	16	6	—	—	1	1	—	—	1	—	—	—	—	—	—	—
18	18	6	—	18	24	—	27	7	—	25	17	2	—	1	7	2	—	7	—	—	—	—	—	—	—
19	18	7	—	15	27	—	18	17	—	26	22	3	—	3	8	5	1	9	—	1	—	3	—	—	—
20	3	12	—	4	31	—	8	24	—	24	36	5	—	2	7	7	—	8	3	1	—	14	—	—	—
21	1	16	—	2	27	—	2	22	—	7	44	2	—	2	3	10	3	3	10	3	—	11	2	—	—
22	—	2	—	—	14	—	—	12	—	3	30	—	6	2	2	20	2	2	21	2	—	6	11	3	—
23	—	—	—	—	1	—	—	1	—	—	21	—	11	2	—	12	—	—	13	1	—	3	21	1	—
24	—	—	—	—	—	—	—	—	—	—	2	—	3	—	—	7	—	—	8	—	—	—	23	2	—
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	3	—	—	—	15	1	—
26	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	1	—
	59	56	3	83	175	22	73	90	1	133	194	12	20	13	31	65	6	30	58	8	77	37	75	8	23

*) Among these also *M. neglecta.*

rom the Nyborg Fjord.

July 23.—31. 1917.				August 15. 1917.				August 30. 1916.				September 13. 1917.				October 2. 1917.				Okt. 16.– 19. 1917.			Novbr. 20. 1916.			Decbr. 11. 1917.	
♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	2	—	—	—	—	—	—	—	1	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	2	—	—	—	1	—	—	—	3	—	—	—	4	—	—	—	3	—	—	1	—	—	—	—	—
—	—	—	3	—	—	—	1	—	—	—	6	—	—	—	3	—	—	—	—	—	—	1	—	—	—	—	—
—	—	—	4	—	—	—	6	—	—	—	22	—	—	—	4	—	—	—	5	—	—	2	—	—	—	—	—
—	—	—	5	—	—	—	7	—	—	—	34	—	—	—	15	—	—	—	—	—	—	2	—	—	—	—	—
1	—	—	7	—	—	—	17	—	—	—	58	—	—	—	14	—	—	—	8	—	—	2	—	—	2	—	—
2	—	—	9	—	—	—	45	—	—	—	75	—	—	—	16	—	—	—	—	—	—	2	—	—	1	—	—
3	—	2	2	—	—	—	70	—	—	—	108	—	—	—	26	—	—	—	10	—	—	3	—	—	2	—	—
2	—	4	—	1	—	—	54	1	—	—	168	—	—	—	38	—	—	—	28	—	—	7	—	—	2	—	—
2	—	2	—	18	—	2	35	32	—	—	259	3	—	—	83	3	—	—	75	3	1	5	12	—	7	1	1
2	—	4	—	24	—	2	24	70	1	1	170	5	—	3	60	19	—	1	115	13	1	4	19	—	11	2	1
2	3	2	—	3	12	2	5	50	5	2	95	4	—	3	27	29	—	2	177	16	1	7	32	—	22	6	1
—	8	—	—	—	11	1	1	10	16	8	44	3	1	5	6	34	1	14	142	14	4	13	46	15	16	7	4
—	2	—	—	—	2	3	—	2	26	12	16	1	2	5	—	1	3	23	56	5	7	12	25	51	2	4	6
—	—	—	—	—	1	—	—	1	9	4	1	—	—	—	—	—	1	9	10	1	1	2	8	48	—	1	5
—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1	3	—	—	—	—	11	—	—	2
—	—	—	—	1	—	1	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	—	1
—	2	—	—	—	2	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
—	4	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	21	14	34	47	31	11	266	166	65	27	1062	16	3	16	303	86	5	50	632	52	15	63	142	134	65	21	21

Table 5.

Measurements in mm of *Mysis neglecta*

mm	Jan. 21.–28. 1918.			Febr. 20. 1917.			March 7.–12. 1918.			April 14. 1917.		May 15. 1918.		June 4. 1917.			June 25. 1917.				July 3. 1917.		
	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	♂	♀ without eggs	♂	♀ with eggs	♀ without eggs	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	Young
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*) —	—	—	**) —
2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	—	—	2
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	67	—	—	17
5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	27
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	30
7	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	30
8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
9	—	—	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
10	—	—	1	—	—	2	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—
11	1	—	1	—	1	3	—	—	1	2	1	2	1	—	—	—	—	—	—	—	—	—	—
12	—	—	2	3	3	2	6	—	1	1	1	2	3	—	—	1	—	—	—	—	1	—	—
13	2	—	—	4	4	—	8	—	3	1	2	2	4	1	—	3	—	—	—	—	1	—	—
14	2	3	—	11	9	—	16	1	2	6	5	11	4	4	—	2	2	—	1	—	2	—	—
15	4	4	—	10	13	—	7	7	1	14	12	16	8	10	—	2	8	—	2	—	2	—	—
16	2	2	—	5	13	—	—	9	—	8	17	11	7	14	1	3	4	1	4	—	7	—	—
17	—	1	—	—	5	—	—	5	—	1	18	2	16	4	6	6	4	8	3	—	7	2	—
18	—	—	—	—	1	—	—	—	—	—	8	—	28	2	18	5	3	12	3	—	4	7	—
19	—	—	—	—	—	—	—	—	—	—	2	—	7	—	20	4	1	27	3	—	—	13	—
20	—	—	—	—	—	—	—	—	—	—	—	—	1	—	9	1	—	36	2	—	—	20	—
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—	—	—	10	—
22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—
	11	10	5	33	49	9	37	22	10	34	67	46	79	35	55	27	22	86	18	77	24	55	113

*) Among these also *M. flexuosa.*

**) Some *M. flexuosa* among the smallest individuals

from the Nyborg Fjord.

July 31. 1917.				Aug. 11. 1916.				Septbr. 13. 1917.				Septbr. 27. 1916.				Octbr. 19. 1917.				Novbr. 13.–20. 1917.			Decbr. 11. 1917.		
♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ with eggs	♀ without eggs	Young	♂	♀ without eggs	Young	♂	♀ without eggs	Young
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	8	—	—	1	—	—	—
—	—	—	1	—	—	—	1	—	—	—	4	—	—	—	1	—	—	—	11	—	—	4	—	—	—
—	—	—	2	—	—	—	15	—	—	—	10	—	—	—	3	—	—	—	13	—	—	23	—	—	—
—	—	—	4	—	—	—	25	—	—	—	5	—	—	—	7	—	—	—	6	—	—	27	—	—	—
—	—	—	2	—	—	—	30	—	—	—	17	—	—	—	10	—	—	—	14	—	—	16	—	—	—
—	—	—	1	—	—	—	88	—	—	—	23	—	—	—	13	—	—	—	13	—	—	25	—	—	1
—	—	—	1	—	—	—	117	—	—	—	48	—	—	—	22	—	—	—	28	—	—	34	—	—	3
—	—	—	2	3	—	5	108	—	—	—	63	—	—	—	43	—	—	—	36	1	—	40	—	—	5
7	—	1	1	18	—	24	23	3	1	—	33	1	—	—	93	—	—	—	71	3	—	58	—	—	4
12	—	2	—	1	—	10	3	4	1	1	19	3	—	—	121	12	—	—	78	12	—	61	2	—	2
5	—	4	—	—	4	7	—	3	3	1	5	5	—	1	92	19	—	1	30	29	—	73	9	—	12
1	1	2	—	14	1	—	—	—	4	1	—	—	—	8	30	3	—	33	17	17	7	65	11	—	24
—	1	1	—	23	1	—	—	1	2	1	—	1	3	10	7	1	—	20	—	1	20	13	—	1	13
2	—	—	—	27	—	—	—	2	1	—	—	—	3	3	—	—	—	2	—	2	10	4	—	1	4
—	—	—	—	3	4	1	—	—	1	—	—	—	2	1	—	—	—	2	—	—	—	1	—	—	—
—	1	—	—	—	13	3	—	—	—	—	—	—	1	4	—	—	—	2	—	1	1	—	—	—	—
—	5	—	—	—	26	3	—	—	—	—	—	—	2	3	—	—	1	—	—	—	1	—	—	1	—
—	2	—	—	—	8	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
27	10	10	15	89	57	54	410	13	13	4	228	10	11	32	442	35	1	60	326	66	39	445	22	3	68

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